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1910

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Program of Meetings

March, 1909, to March, 1910.

March 12, 1909. Open Meeting. Paper by Professor R. T. Fisher. Some Notes on the Management of White Pine in Massachusetts.

March 26, 1909. Open Meeting. Paper by W. L. Hall and Hu Maxwell. The Relation Between Surface Conditions and Streamflow.

April 9, 1909. Open Meeting. Address by Gifford Pinchot. The National Application of the Forester's Point of View.

April 28, 1909. Executive Meeting.

December 8, 1909. Open Meeting. Illustrated lecture by R. S. Kellogg. The Forests of Alaska.

December 30, 1909. Open Meeting. Paper by Professors Filibert Roth and Henry S. Graves. Training of the Professional Forester in the United States.

January 19, 1910. Open Meeting. Paper by Fred G. Plummer. We Must Grow Timber.

February 17, 1910. Open Meeting. Paper by W. W. Ashe. Management of Loblolly and Shortleaf Pine.

February 21, 1910. Executive Meeting.

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March 10, 1910. Open Meeting. Paper by Henry S. Graves. The Selection System of Cutting.

March 17, 1910. Open Meeting. Lecture by Dr. A. Aaronsohn. Some Vegetal Aspects of Palestine (Illustrated).

March 24, 1910. Executive Meeting.

March 31, 1910. Open Meeting. Paper by Treadwell Cleveland, Jr. Forests as Gatherers of Nitrogen.

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THE SELECTION SYSTEM

HENRY SOLON GRAVES

Presented before the Society March 10, 1910

Theory of the System

The selection system is applicable to selection stands; that is, those in which trees of different ages are represented. The principle of the system is to cut at a given time the old mature trees and others which have passed their effective growth, to protect and aid the growth of the immature trees, and to secure reproduction in the openings made in the cutting. The system is called the selection system because at any given cutting the trees removed are scattered here and there singly and in small groups throughout the stand. A given cutting never clears a stand, but makes only small openings.

An ideal selection stand is one in which trees of all ages from the seedling to the mature tree mingle together in full proportion. Even in the best selection forests, however, every year in the rotation would not be represented. If the rotation were 100 years, there would never be trees of every age up to 100 years, because seed is only produced at intervals. It is an ideal selection forest if all *age-classes* are proportionately represented. Thus if the rotation were 100 years and the age-classes comprise twenty years each,

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the oldest age-class should occupy in the aggregate about 20 per cent. of the area and the other classes should have enough trees so that as each comes to maturity it will occupy 20 per cent. of the area.

In making selection cuttings in this ideal forest the oldest age-class would be removed during the first twenty years. Then the trees in the next age-class would begin to come to maturity and would be cut during the following twenty years. If successful reproduction were secured this process might be continued indefinitely.

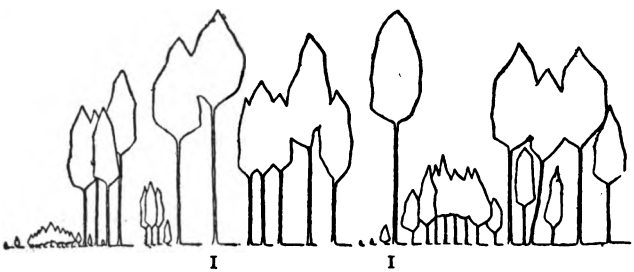

Fig. 1.

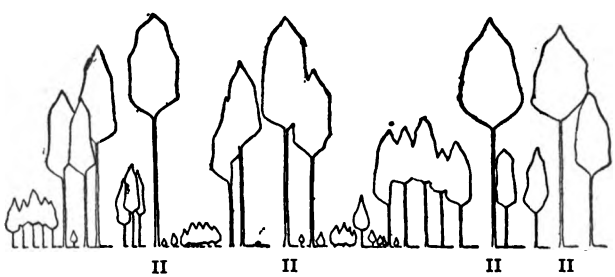

Fig. 2.

The theory of the selection system is illustrated above. Figure 1 represents a fragment of a selection forest just before cutting. The trees designated as "I" are mature and are therefore removed. Fig. 2 shows the same stand after twenty years. The trees marked "II" in Fig. 2 are now grown into the mature class and are ready for cutting. All trees have grown both in height, diameter, and crown surface. Several trees have disap-

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peared as a result of the mutual crowding. Small groups of young seedlings are found growing in the openings made by cutting.

In some cases a stand is cut through every year. In the theoretical example this would mean cutting each year one-twentieth of the oldest age-class. Usually it is impracticable to make annual cuttings, and the stand is cut through periodically. The interval between cuts is called the *cutting cycle*. In Europe the cutting cycle is usually about ten years. In this country the interval between cuts will more often be from twenty to fifty years.

Principles of Limiting the Cut

In making selection cuttings the design is to remove primarily trees in the mature age-class. Even where all age-classes are well represented, they are usually not so clearly differentiated as in the theoretical example shown on page 2. When the market conditions are at all favorable, not only the trees in the oldest age-class but also those in the younger classes are merchantable. The restriction of the cut to the oldest class would mean then that there is a market for many of the trees left standing as the basis for the next cut. There is always a temptation to increase the cut as much as possible, in order to show a large return and to reduce the cost of logging. It is obvious that there must be some definite principles of restricting the cut to prevent the removal of such a large proportion of the trees of intermediate ages and sizes that succeeding returns will be greatly diminished, and to prevent disturbing the arrangements of the age-classes to such a degree that the continuance of the selection system is impossible.

There are two fundamental principles which must never be lost sight of:

1. The maintenance of the increment.

2. The continuance of a proper representation of age-classes.

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If the age-classes are all represented in proper proportion the problem is simple. The increment is determined in advance and the cut limited to this amount. The trees removed are selected primarily among the oldest trees. If a given stand is cut through each year, there is removed an amount equal to the annual increment of the whole stand. If the stand is cut every ten years, each cutting removes an equivalent of ten years' increment. As all age-classes are at hand, there are, continuously, trees growing into the merchantable class as a basis for the next cut.

The theory may be illustrated by a concrete example. Before cutting in a given stand, its annual growth is determined. Suppose that the stand comprises 100 acres, the annual growth is found to be 250 board feet per acre, and the cutting cycle is ten years; 2,500 board feet per acre or 250,000 feet on the whole tract may be removed at each cutting, provided there are no special conditions to modify this amount. In a stand in which the age-classes are well represented, the proportion of the total area uncovered by a given cutting, that is, the aggregate of all openings taken together, is approximately equivalent to the rotation divided by the cutting cycle. Thus if the rotation is 150 years and the cutting cycle is twenty-five years, each cutting uncovers in aggregate of all small openings one-sixth of the area.

Unfortunately, in this country the age-classes are usually not represented in proper proportion. The selection system is chiefly used in cutting in virgin forests. The characteristic form of an untouched virgin forest is that of a selection forest. The different age-classes are represented, but the range of ages is very great and it is necessary to classify the trees by wide age-classes. Thus in a forest in northern Idaho the oldest trees may be over 500 years old. If one uses age-classes of seventy-five years or so, there are at hand all stages. But the trees over 200 years old are growing very slowly and in many instances the desire of the owner is to cut at least to a limit of about 150 years. Such a cutting

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would ordinarily uncover fully 50 per cent. of the area of the stand. This means that the arrangement of age-classes is disturbed at the outset. In the future, of course, trees will not be allowed to grow to be 400 years old. The rotation will probably not exceed 150 years. From the standpoint of a 150-year rotation, a virgin forest having a range of 300 or 400 years has an excess of the oldest age-class. There is an accumulation of old stock of trees mature and slow-growing which ought to be cut. The removal of the oldest age-class uncovers a disproportionately large part of the area and a very much larger amount of timber than the increment during the succeeding cutting cycle.

Under these conditions the selection system can not be carried out in strict conformity to the ideal. If the conditions are such that a large proportion of the trees should be cut, because old and slow growing, the cutting ceases to have a selection character. In general a continuance of the selection system is possible if the aggregate of all openings does not exceed 40 per cent. In the virgin forest, with its wide age-range, the restriction of the cut is secured in practice by the use of the average diameter limit.

The Diameter Limit

The purpose of a diameter limit is to aid in restricting the cutting to those trees whose growth no longer represents a return satisfactory to the owner. The trees which are thrifty and growing rapidly are left standing, regardless of their age, as a basis for a later cut.

It is, of course, impossible to investigate the growth of each tree before cutting. It is, therefore, customary to determine in advance of cutting the average diameter at which trees cease to yield a satisfactory growth. Unless there are some special silvicultural reasons for modifying it, this limit is used in planning the work of cutting and as a guide and check in selecting the trees.

Whenever possible, the diameter limit of effective growth is determined by a thorough local investigation. Such a

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study will show the rate of growth of stands cut to a number of different diameter limits and will enable the owner to fix upon that limit which will result in a return most satisfactory to him. In making the study, the forest is first analyzed, to determine the average number of sound trees of different diameters. It is then assumed that all trees above a fixed diameter will be cut and those below it left standing. Of course, this will not be carried out in the cutting, but usually the trees left standing above a limit about equal in volume those cut below it. An inspection of the forest shows that the limit will fall within a comparatively narrow range. Thus in Maine, it is readily seen that the average diameter limit of spruce will be somewhere between eight and fourteen inches. Accordingly, a computation of increment is made on the basis of cutting to eight, ten, twelve, and fourteen inches. The limit which shows the most satisfactory returns in volume or in interest on the investment, according to the owner's wishes, is selected as the guide for the cutting.

This limit may be modified slightly by special silvicultural considerations, such as danger from windfall, reproduction. etc. These points have usually a greater bearing on the actual selection of the trees than the fixing of the average limit. A limitation of cut based on this method of study maintains the increment of the forest and guarantees succeeding cuts at short intervals.

Sometimes it is necessary to begin cuttings before an adequate study of growth can be made. This happens very commonly in the National Forests when there have not been time, men, or money to make the investigations, and the sales of timber can not wait for possible later appropriations for such work. In this event the forester aims to cut only those mature trees which are obviously no longer making an effective growth, and he leaves the thrifty trees for a later cut. Thus, while no study of growth is made, the limitation of cut is really based on growth.

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Application of a Diameter Limit

In selecting the trees for cutting one takes all trees above the diameter limit determined upon, unless there is some reason for leaving them, and leaves all trees below it, unless there is some reason for taking them. The reasons for leaving trees above a chosen diameter limit are the following:

1. Where it is necessary to leave one or more trees for the distribution of seed in an opening.
2. Where the removal of a tree would expose a group of trees below the limit to damage by windfall.
3. Where a tree is very thrifty and increasing in volume and value very rapidly.
4. Where the removal of a tree or group of trees would result in erosion or serious damage to the soil by desiccation.
5. Where it is desirable to leave a tree or trees for æsthetic reasons, as, for example, near roads or other public places.
6. Where the policy of management requires the leaving of a few prime trees for the production of exceptionally high grades.

The circumstances under which trees below the limit are cut are as follows:

1. Where trees are defective.
2. Where trees are growing very slowly and are unlikely to remain sound till the next cut.
3. Where trees are of poor development and are retarding the growth of others of greater promise.
4. Where the removal of trees of poor promise will aid reproduction.
5. Where it is necessary to cut patches clear, because the trees would not withstand the wind.
6. Where trees will inevitably be injured by the felling of larger trees.

Defects of a Rigid Diameter Limit.

In the northeastern woods it has for a good many years been customary for lumbermen to restrict their cuttings to

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the largest trees. They set a diameter limit and instruct the cutting crews to take only trees above that size.

The diameter limit method of the lumberman is a purely mechanical rule of thumb. All merchantable timber above the limit is cut, and none below, except such as may be required in the logging operations. It is assumed that there is a supply of near-merchantable timber which will constitute the next cut. As a matter of fact, there is often a deficiency of thrifty poles capable of growth, and not uncommonly a large number of these poles are cut for skids, bridges, and other purposes in logging the mature timber.

Cutting to a fixed diameter limit disregards entirely the condition of the trees from the standpoint of health and possibilities of growth. The theory of the whole plan is that there are half-grown trees which will in a short time grow to full merchantable size. There are, however, in every virgin forest many trees below the diameter limit which are old, and will produce little growth, and may not live or remain sound until the next time the area is cut over. Naturally these trees ought to be cut and utilized. On the other hand, there are many trees just above the diameter limit which are growing very rapidly and which it would be good business policy to leave standing. Again, the assumption is made that reproduction will take care of itself. Under the scheme of cutting to a rigid diameter limit this will not be the case. In a great many openings reproduction of the species desired will fail entirely because of the removal from the neighborhood of all trees capable of bearing seed. As the work is usually conducted, a large amount of the small growth is injured through carelessness in logging. Some of this damage is necessary, but much of it is the result of thoughtlessness. Again, the limitation of the cut itself is often a farce. Formerly when only large trees were merchantable, there was little temptation to cut small timber. Ordinarily, the stumps were cut very high and a rough rule was sufficient to prevent the choppers from taking

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trees below, say, twelve inches on the stump. Under present conditions a twelve-inch limit measured on the stump is a different matter, because the trees are sawed, and under good logging methods the stump-cut is well within the root swelling. A twelve-inch limit now is equivalent to about a ten- or eleven-inch limit under the old régime. It is seldom that the felling crew is required to measure the trees before cutting, and inspection is very lax; so that even when a company has the best intentions, the plan fails to be properly carried out.

Another defect of the rigid diameter limit plan is that the limit itself is determined very largely by guesswork and tradition. A twelve-inch limit under certain conditions may be conservative from the standpoint of leaving the forest in a fairly productive condition. In other conditions an owner may be deceiving himself as to the rate of production after cutting. As a matter of fact, this is exactly what is constantly happening. In many cases the owners have entirely overestimated the yield capacity of the forest under their method of treatment, and in the case of large corporations which are counting on an indefinite production this will be a serious matter. It would be wise business policy for such owners to determine what their forests can produce under a proper selection system, and then practice that system in the manner indicated in the previous section, so as actually to secure the production desired.

Provision for Reproduction

In the management of a selection forest the aim is to secure prompt reproduction of a suitable species in the openings made in lumbering. In some forests, trees of intermediate size capable of bearing seed are so well distributed that it may not be necessary to leave any large trees for this special purpose. In other cases the intermediate seed-bearing trees are scanty, or not always properly located, so that some provision for seed distribution must be made from among the old timber.

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Then again, in mixed forests the intermediate trees near an opening may not be of the species most desired. The forester must endeavor to secure a distribution of seed by leaving seed trees properly located. In leaving a seed tree above the diameter limit, one must bear in mind that it involves an actual investment, for the tree might otherwise be taken out and sold. If the tree is salable now, but will not be so at the next cut, one invests its value in reproduction. If it is sound now and likely to remain so till the next cut, it is merely a question of deferred profits. In any case one must be certain that a special seed tree is required and that it will answer the purpose for which it is left.

Successful reproduction depends not only on a proper distribution of seed, but also on the conditions for germination and for the development of seedlings. The problem is very simple with tolerant species, for these are able to grow in very small openings and often there is already a good reproduction established where the openings are to be made. With intolerant species, on the other hand, special measures often have to be taken if they are to be reproduced successfully. If such measures are not taken, other more tolerant species may occupy the opening to their exclusion. It is absolutely necessary that an opening be made large enough not only for a start of the trees, but to enable them to grow straight and with thrift. It is, therefore, sometimes necessary to enlarge an opening beyond what is necessary to remove a single mature tree. In such a case one would aim to cut several trees in groups, it being often necessary to cut trees under the diameter limit. Usually, however, this can be done without cutting medium trees of large promise.

Protection from Windfall

Very commonly a selection cutting would result in windfall among the trees left standing unless this point is considered in the location of the trees to be cut. Sometimes it is necessary to cut whole groups clear, often as large as an

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acre, because they can not be thinned without windfall. In many cases a tree or group of trees above the diameter limit must be left standing to protect the surrounding stand.

Cutting Small Trees for Improvement

The struggle for space in a selection forest is very great. Not only do the old trees overtop and crowd those coming up between and below them, but there is crowding and suppression by the middle-aged of those younger and there is mutual crowding among themselves. A poorly developed tree of small promise may often injure several trees of better form and species. The removal of such trees greatly increases the total increment of the stand.

Influence of Market Conditions

The principles given in the foregoing outline are subject to restrictions in their practical application by poor market conditions.

In the first place, it may happen that only a certain number of the species are merchantable. Thus, for example, in the Adirondacks there are certain areas where a number of the hardwood species can not be marketed at all. Sometimes the best individuals of a species can be cut at a profit, but the crooked and defective trees are not merchantable. Ordinarily, it is the merchantable species which the forester desires to reproduce. If he can not cut the less desirable trees, he is forced to leave the ground practically in their possession for reproduction. This would result in a reduction in the proportion of the best species. There is, however, no alternative except to wait for a market; but this is often, if not usually, impracticable. Under such circumstances the forester leaves the forest in the best condition for reproduction possible under the circumstances, but he must expect that there will be certain areas in which the poor species will gain the upper hand.

The larger trees which can not be sold—either because

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they are of poor grade or of poor species—usually interfere with the growth of trees of better character. Their removal would increase the increment of the forest by releasing the trees which they crowd and replacing them with reproduction of valuable species. But this would be an actual outlay which often would not be justified. The experiment has sometimes been tried of girdling these trees. Doubtless this experiment would be practicable in certain instances in public forests, but there are usually more important cultural operations which demand the use of such money as can be devoted to these purposes. Sometimes the danger of injury to young growth by the overthrow of such dead trees by the wind, and injury by the breeding of insects, would fully offset the advantages secured. As a rule, therefore, the cutting or girdling of large mature trees which can not be sold is not advisable.

A poor market means that small individual trees can not be sold, and hence that the cutting of trees below a diameter limit which are defective, unpromising, or interfering with reproduction and with the growth of other better trees, would be impossible without considerable expense. The amount of money which can be spent on cutting small trees for these purposes depends on the returns which would result. The question must be worked out, like any other proposed investment.

Cost of Operation

The cost of operating the selection system depends on the following factors:

1. *Increased Cost of Logging.* In any selection forest, like most of our virgin forests, the lumberman has to go over a good deal of ground for the timber. If there is a further restriction of the amount cut by limiting the size to only the largest trees and by leaving seed trees, the cost of logging per unit of volume is further increased. As a matter of fact, most of the merchantable trees left standing are small and the profit from them is insignificant. Often

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there is no profit from them at all, or there may be actual loss in logging them. If these logs are not cut, the average grade of logs is increased. The higher value per unit is usually enough to equal, if not to exceed, the increase of cost in logging.

Lumbermen usually contend that the trouble to the choppers in looking for marked trees adds to cost. As soon, however, as the crews become accustomed to the work, there is no increased cost due to this cause.

2. *Cost of Protecting Young Growth.* The felling crew has to be careful not to injure small trees in felling, and the skidding crew must avoid breaking down small trees and barking those of medium growth. A careful chopper does not throw his tree into groups of young growth in any case; and an intelligent swamper always avoids small trees, to save himself needless labor. An unintelligent crew will do a great deal of damage. A careful crew is able to reduce this damage to a minimum without extra cost.

3. *Increased Cost of Construction Work.* Ordinarily a logger uses for skids, building bridges, skidding roads, etc., the straight, well-formed trees of medium growth which happen to be most convenient to his work. These are exactly the trees which the forester would save. If the logger must go to a greater distance to secure this material, and if it is less easily handled, there is a cost which adds to the total cost of lumbering.

4. *Cost of Seed Trees.* If seed trees are left which have a value now but will deteriorate before the next cut, an item of cost is added. Ordinarily, such trees are not left. Their total would be so small as to be insignificant in a large operation. If thrifty trees are left which will live till the next cut, it is an investment comparable to that of leaving the small merchantable trees. The increase of stumpage value will more than cover the investment, even if there were no increase in volume by the growth.

5. *Cost of Improvement Work.* Under this head are comprised special measures to aid reproduction and to

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improve the condition of the small trees. Usually this investment is not made at all. In case of valuable species improvement work is often desirable and profitable.

Intensive Development of the Selection System

It has been shown that the selection system is usually the first development of forestry in a newly developed country. With a virgin forest of selection form and with a market only for the largest and best trees, the lumberman's first cutting resembles a conservative selection cutting, even though not designed by him to be such. With unfavorable market conditions, it may thus be applied in a crude or extensive manner. On the other hand, with good market and logging conditions, it may be developed into one of the most highly intensive of all systems, as is illustrated in certain forests of Europe.

In the use of most systems of silviculture the cuttings result in stands which are regular or approximately even-aged; while all ages are represented in the forest, each age-class occurs in even-aged stands, each covering a whole compartment or part of a compartment. In the selection system, on the other hand, trees of different ages are mingled together everywhere, individually or in small groups.

In the less intensive application of the selection system, as described in the foregoing pages, the handicaps of markets and transportation prevent more than a rough protection and care of the young growth. If there is a market for all products and a system of permanent roads, the cutting cycle may be reduced even to a single year. The aim is then to make provision, as fast as the forest permits, for a proper representation of age-classes; reproduction of the right species is secured, if necessary, by planting; improvement work is done throughout the given stand so as to give each tree the right amount of space for its best development; deteriorating trees, those of poor form, and injured trees are cut at the proper time. In other words, instead of

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handling the forest under long cutting cycles and in large logging units, the management is intensified, the units are reduced in size, and each stand is cut over at frequent intervals.

This intensive development of the selection system is applied in a number of special forms in Europe. In general, the tendency is to transform the forest to the group-selection form, in which each age-class occurs in groups instead of in the single-tree arrangement. The groups vary in size from fifty feet to several hundred feet across, are irregular in form of area, and their location irregular in relation to each other; but the aim is to secure an equal aggregate area of each age-class in each compartment. This development is really a series of even-aged groups, instead of one of larger even-aged stands, and means a much more extensive management if each group is carefully handled for its best development. A prominent European forester, Dr. Ney, has carried out this idea still further and has merged the various groups of each age-class together in the form of regular or irregular strips.

Results of the System

The selection system results in an all-aged form of forest which is well adapted to the protection of mountain slopes. It is a form most admired from an æsthetic standpoint and hence well adapted to public forests used as recreation grounds.

At any given time the amount of merchantable timber is less than on a like area of a mature even-aged forest, because part of the area is occupied by small trees. Comparing two forests, one of which has separate, even-aged stands of different ages, while the other is managed on the selection system, with trees of different ages mingling together singly or in groups, it is usually maintained that the increment of the latter is the less. In the former, trees grow in even competition with each other and without cover overhead. In the

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selection forest there is a retarding of growth of the individual trees, because of the shade either overhead or from the side during a large part of the trees' life. In the selection stand there is a very large number of trees, because of the overlapping of the crowns; but usually this advantage is not enough to equal the retarding of the growth by shading. There is no question that with intolerant species the increment is the greatest under one of the even-aged systems. With tolerant species and intensive management it is probable that as large an increment can be secured by the selection system as by any other.

The development of the individual trees in a selection forest is somewhat different than in an even-aged stand. The trees are apt to have larger crowns and larger diameter than those produced in an even-aged stand. Because of the larger crowns, the clear boles are less and the knots larger. The trees pass through periods of retarded and full growth, and hence the grain of the wood is less even.

Choice of the Selection System

The selection system is used in forests where the market conditions are such that only a limited class of trees can be cut at a profit. It is used in those all-aged forests in which the various sizes are represented and it is less profitable to remove the medium trees than to save them for growth and later cutting. It is an excellent method for the handling of a woodlot which is culled frequently for wood, poles, posts, rails, and occasional sawlogs for home use and for sale. It is the ideal system for forests on ridges and slopes where it is important to keep a continuous forest cover to control run-off, or to prevent erosion. It is particularly applicable to forests composed of tolerant species; but it may be used successfully with intolerant species, provided that in making cuttings the openings are large enough to secure reproduction and to permit the new stock to develop.

It is not applicable to even-aged stands. As the market in

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a given region improves and as the smaller sizes of trees and those of inferior species become merchantable for fuel and other purposes, the tendency is away from the selection system. As intensive methods become practicable, the tendency is to use one of the systems resulting in a clearing and an even-aged new stand, rather than to apply the intensive selection system. This is well seen in continental Europe; there the selection system is most extensively used in the protection forests and the less accessible regions of the mountains where the market is still very poor. In the commercial areas with good markets, it is the clear-cutting systems and the shelterwood systems which are most common, and, as a result, the common form of forest is even-aged.

In this country the better-settled districts have an increasing proportion of even-aged stands on the cut-over lands. This is partly because of the prevalent method of cutting, but partly because fires have followed cutting and made clearings. The second growth has more the character of an even-aged forest than otherwise, particularly among the conifers.

Whenever the market conditions are good and the forester has a choice between the selection system and some other, the choice of system is based on the question of meeting the owner's object with reference to present and future returns.

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THE LOG SCALE IN THEORY AND PRACTICE

HARRY D. TIEMANN

Contributed

The log scale has been for so long a time a hackneyed subject of discussion, and has been attacked from so many points of view, that to bring it up once more would seem almost inexcusable without particularly good reason. Yet the very fact that the means of reducing round logs to some tangible unit of measure is still a mooted question shows that the problem has not yet reached an altogether satisfactory solution.

My excuse for again opening the subject is the belief that a satisfactory solution of the problem is possible, as I shall attempt to show in the following pages, and to offer for the purpose a new log-rule based on a new principle.

Log-rules have been worked out empirically from measurements, mathematically from theoretical considerations, graphically from geometrical diagrams, and in a purely hit-or-miss fashion, or by a combination of several methods. Yet, no rule has proved entirely satisfactory. Theory and practice appear to work together very poorly in the case of measuring round timber. Does the incongruity follow on the innate nature of the problem, or is there some way out of the difficulty? We should at least be able to answer this question, and show the reason for the answer.

Let us first examine the theory of scaling logs and, when this is perfectly clear, apply the theory to actual cases—test it by experimental measurements—and if it then holds good we shall be enabled to explain the incongruities and to point out the way to a possible solution, as well as to show the directions which lead only to confusion.

It is the object of this article to explain some of the underlying principles, which are frequently misunderstood, then to show how a theoretical log-rule may be applied to

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logs in actual practice, and finally to offer a log-rule which, although it may require slight modifications in numerical values, is not only based on correct principles, but corresponds to actual results obtained at the mill and is applicable to long logs as they occur in practice.

The Theory of the Log Scale

To find the cubical contents of a log is a simple matter, and to determine how much a given log with a known "rise" in taper would saw out as boards under given conditions is also comparatively easy. In fact, an experienced sawyer can tell this pretty closely from his judgment. If this were all there were to determine, there would be no problem. Nor would there be a problem if all logs were cylindrical. It is the taper, then, which really constitutes the main difficulty and makes a theoretically simple matter exceedingly complex in its practical application.

Another great source of confusion has been a misunderstanding of the fundamental difference between a volume rule and a board-foot rule, and the common attempt to make one rule serve both purposes. It would be almost as reasonable to sell boards by the length, without any regard to their width. This distinction has been well explained by Mr. E. A. Ziegler in his article on Standardizing Log Measures in the foregoing number of the PROCEEDINGS. The difference is strikingly brought out by the curves, Fig. 1. That no rule can at the same time and in the same set of figures give values indicative of both the volumes and the board-foot contents of logs, is evident upon a moment's reflection. It would seem that with a correct understanding of the principles, the necessity for the two classes of rules might be done away with. In fact, the *volume* rules should be entirely discarded; for what is the advantage of expressing volumes in numerous artificial "standards," such as the 16-inch "Blodgett" standard in Maine or the 19-inch "standard" in New York, instead of directly in cubic feet? Absolutely no additional accuracy in scaling is gained

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thereby, while endless confusion results, with the establishment of any number of miscellaneous rules, each expressing the results in different terms or "standards." Some rules, like the New Hampshire Rule and the Hoyt Rule, even express the volumes in the nomenclature of board-feet, a totally erroneous and misleading idea. Wherever *volume* is the controlling factor and diameter is of no consequence, the contents should be expressed directly in cubic feet. There appears to be no other excuse than ignorance of facts for thus measuring volumes in indirect and misleading terms instead of the cubic foot.

In all saw timber, where the *diameter* is an important consideration, a correct board-foot rule should be used.

A volume rule is always proportional to the square of the diameter, and is, as just stated, often erroneously expressed in terms of board-feet, in an attempt to make it apply to saw-logs by using a constant "conversion factor," thus leading many to suppose that it is in reality a board rule. The use of this constant conversion factor does not help matters, however, since the resulting values, although expressed in board-feet, remain proportional to the cubic volume. Such rules are correctly applied to the middle diameters of the logs, for it is found that, as a rule, the cross-sectional area at the middle, multiplied by the total length, gives the volume with reasonable accuracy for practical use. This will be observed by an examination of Table III. (The diameter at the center of gravity of long logs has been found to give more accurate measurement of volume, but is impracticable to obtain in commercial work.) The board-foot rule, on the other hand, takes into consideration the fact that the ratio of the cubical volume to the number of board-feet obtainable from a log is not a constant, but varies with the diameter. Thus the ratio of cubic feet to a thousand board-feet is less for large logs than for small ones. Let us take a concrete example and compare it with figures taken from measurements made at the mill, as later explained. A log 8 inches in diameter at the small

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end and 10 feet long, if "slash-sawed" as at Case A, would yield 24 board-feet. (Table VI.) Its volume in cubic feet (neglecting taper for simplicity) would be 3.49 and the ratio $\frac{3.49}{.024} = 145$.

A log 16 inches in diameter and 10 feet long would yield 112 board-feet, and its volume would be four times as great, or 13.96 cubic feet. The ratio would then be $\frac{13.96}{.112} = 125$.

So also the ratio for a log 20 inches in diameter would be 119. Thus it is seen from actual measurements that the ratio decreases as the diameter increases.

Now the factor of taper does not materially affect the total volume when the log is measured in the middle, because if the form of the log approximates a paraboloid, the loss due to taper on the small end is exactly counterbalanced by the gain on the large end. Consequently, the element of taper does not enter in as a serious factor in considering *volume* rules. Of course it does not strictly follow that logs of the same middle diameters but of varying tapers or form factors have the same volumes. But for the same species the variation in volume due to differences of taper may be safely left out of consideration for practical purposes.

This is not so in the case of saw timber, however, and particularly if the measurement is made at the small end. The longer the log the greater the taper factor becomes. As the tendency is more and more to cut logs full lengths in one piece, particularly spruce and structural timbers, the effect of taper in its relation to scaling for saw timber becomes one of prime importance.

All true board-foot rules, so far as the writer is aware, apply to the small end diameters of the logs. For long logs which run well up into the tops, it is manifest that the small-end diameters cannot properly be used to scale the log, unless the log be measured at a number of points, as though cut up into a number of short pieces of not more than 12 or at most 16 feet in length—a method which is ordinarily

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impracticable. Consequently, the tendency is to abandon this class of rules and resort to one or other of the volume rules, calipering the logs in the middle and wrongly using a constant conversion factor to convert the "standards" into board-feet.

On the other hand, the ordinary board-foot rule cannot properly be applied to the middle diameters for the following reason: While, as was said, the loss in cubic volume due to taper on the small end is practically counterbalanced by the gain in volume on the large end, it does *not* follow that the ratio of cubic feet to board-feet is likewise counterbalanced, and consequently loss on the small end is not compensated for by the gain on the larger end. When a log is sawed "around" instead of "slashed"—a device by which the maximum advantage out of the taper is obtained—the compensation is more complete and the ratio of cubic feet to board-feet is more nearly constant, as will be seen by a comparison of the ratios for Mill B, given in Table II, columns 9 and 14. Thus, for illustration, a cylindrical log without taper, 16 feet long and 10 inches in diameter, will saw out more board-feet than a log of the same volume, length, and middle diameter, but with taper. Thus the former would yield at Mill A 64 board-feet, whereas the latter, with average taper, would yield but 55 board-feet, sawed in the same way.

In order to show more strikingly the distinctions between the two classes of rules, Fig. 1 has been prepared. Three curves are there compared for 16-foot logs, the horizontal distances representing board-feet and the vertical distances the diameter inside the bark at the small ends.. One curve represents the actual product, as obtained from Mill A, corrected to exact inch-board and $\frac{3}{16}$-inch saw-kerf equivalents (dash-line). Closely following this curve is that of the proposed rule, $B=\frac{L}{16}\left(\frac{3}{4}\ D^2 - 2\ D\right)$ indicated by a full line. The other curve is the New Hampshire Rule. In comparing the two classes of rules,

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it is necessary to know the taper between the small end and the middle. The average taper of 0.8 inch for all 16-foot logs was used in this case.

It will be observed that the New Hampshire Rule forms an exact parabola of the equation

$$B = \frac{D^2}{16} \times L \times \frac{1000}{115}. \qquad (1)$$

Professor A. L. Daniels, of the University of Vermont, has shown* that an equation of the general form

$$B = a.d^2 + c.d + e \qquad (2)$$

where a, c, and e are constants, d diameter, and B board-feet, is theoretically very nearly correct for saw timber. This equation applied to the corrected Holland Rule gives

$$B = \frac{L}{16}\left(\frac{17}{21} d^2 - \frac{59}{42} d - \frac{5}{7}\right). \qquad (3)$$

By way of comparison, the equation for the "Universal Rule" proposed by Professor Daniels, which applies to the *small-end* diameters, is, for a 16-foot log,

$$B = \frac{L}{16}\left(0.838\ d^2 - \frac{8}{3} d\right) \qquad (4)$$

when *d* is the diameter at the small end.

In the "International Rule" by Professor Judson F. Clark, the log is assumed to be divided into 4-foot lengths, and to have ½-inch rise in diameter for each length. The formula for a 4-foot length is

$$B = 0.22\ d^2 - 0.71\ d. \qquad (5)$$

It should be noted here that this formula is not intended to apply in direct proportion to length, since a rise of ½ inch is assumed every 4 feet.

The Proposed Board-Foot Rule for Long Logs

Both the Universal and the International rules were

* Bulletin 102, Vermont Agricultural Experiment Station, on Measurement of Saw Logs. 1903.

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worked out mathematically in comparison with actual results and are theoretically correct, but they are based on the small-end diameter of the log. In practice, however, the small-end diameter is a very poor measure for the contents of logs, particularly logs over 16 feet in length. As the tendency in the East is more and more to cut logs full length, particularly for spruce, balsam, second-growth pine, and structural timbers, measurements at the small end are not only impracticable but often entirely misleading as a basis for contents. Such logs must be scaled by calipering at the middle, or at several points along the log.

For logs up to 48 feet in length, I have found the middle diameters to serve as a close measure of the cubical contents. *Can the middle diameter be used for a board-foot measure?* If so, we have at last a practical solution of our problem.

If we were to ask whether the middle diameters of long logs could be used as a basis for a board-foot rule in a strictly theoretical sense, the answer must be "no," since two independent variables enter in, taper and length. But a rule applied to the small end is strictly no more correct, for the same reason. There is, however, a point in this problem where the refinements of theoretical variations become less and less, until they fall entirely within the limits of error in practical operations; and when this point is reached, further refinements in theory can add nothing to the correctness of the results. It is this point of balance which it should be aimed to secure in working out any system, and the value of the system is determined by the degree to which it approaches this point. In no sense, however, should the theoretical principles involved be disregarded, but their *relative significance* to the problem in hand must be clearly understood. Having determined this, it may then be decided just what factors may with safety be disregarded without detracting from the accuracy of the results.

Now, by applying a board-foot rule to the middle diameter of a log and in assuming values proportional to length, a certain variable factor is disregarded; namely,

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the unequal influence of unequal taper upon the product in logs of different lengths. If, however, in the light of the principle already stated, we base the rule upon the average taper for a given length, and limit the length to which it is to be applied, so that logs which are longer than the assigned length shall be scaled as two or more logs, the degree of error produced by neglect of this factor may be brought within desired limits. In fact, it is in any case much less than that produced by measuring the small-end diameters, and either neglecting the taper or assuming a given taper every 4 feet or so.

Two great advantages will be gained: practicability in operation, especially for long logs; and greater accuracy in the result.

The rule which I am about to propose is derived directly from measurements taken at Mill A, later described, corrected for exact inch boards and $\frac{5}{16}$-inch saw-kerf. It is based on 224 perfect logs (that is, logs without crooks or defects that would reduce the product). The equation for the proposed rule was derived directly from the curve for 16-foot logs, grouped according to middle diameters. The simplicity of this equation is indeed remarkable, and moreover, it will be seen to be theoretically of correct form. In fact, it would almost seem as though the equation had been first worked out mathematically and then the figures chosen to fit the equation. The reverse, however, is true.

The equation for this rule is

$$B = \frac{L}{16}\left(\frac{3}{4}D^2 - 2D\right), \qquad (6)$$

when D is the *middle diameter* inside the bark and L the length in feet. The equation so closely fits the curve derived from the mill as to make a diagram superfluous. The comparison of the two cases for the 16-foot length is shown in Table II, columns 3 and 4. The rule figured out for diameters 4 to 32 inches and lengths 8 to 32 feet, is given in Table I.

Just what limit of length should be allowed for this rule will depend somewhat upon circumstances and the kind

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of timber scaled. It is accurate for logs 16 feet long. Shorter logs will overrun slightly and larger ones will fall under the values given, since the shorter the log the less will be the taper.

In practice, it is not desirable to measure a log at more than two places, or three at most. I have placed the limit for this rule tentatively at 24 feet, which is reasonable and, according to our measurements, is within admissible limits of error. Thus logs up to 24 feet in length would be scaled once in the middle, a 26-foot log should be scaled as two logs of 13 feet each, and logs over 48 feet in length would require three measurements.

It is interesting to compare the formula for this rule with the formulas for the Universal and the International rules, figured on the basis of middle diameters for 16-foot logs.

Assuming the average taper of 0.8, formula (4) for the Universal Rule becomes, when applied to the middle diameters,

$$B = \frac{L}{16}\left(0.838\ D^2 - 4.34\ D + 3.5\right). \qquad (7)$$

With the International Rule, figuring on 4-foot lengths, with a rise of ½ inch for each length, gives the equation, when applied to the middle diameter, for 16-foot logs,

$$B_{16} = 0.88\ D^2 - 3.28\ D + 1.03. \qquad (8)$$

It is evident, therefore, that our formula is much simpler than either of these.

Recapitulation of the Main Principles

Before describing the study which forms the basis of this discussion, let us first briefly review some of the important principles brought out.

1. A volume rule and a board-foot rule are essentially distinct in character, and multiplying the values of the volume rule by a constant factor to express them in terms of board measure does not convert them into board-feet.

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2. The middle diameter serves very closely as a measure for the cubical volume of logs, since the loss in volume due to taper on the small end is compensated for by the gain in volume on the large end. It is superfluous to convert volume rules to standards, since the volume may be just as readily expressed directly in cubic feet.

3. Volume rules are incorrectly applied to the diameters at the small ends, because they cannot correctly account for taper when thus applied.

4. The usual board-foot rule is correctly applied only to the small ends of the logs. In the case of long logs running up into the tops, this is entirely inadequate for giving the correct saw value of the logs.

5. A board-foot rule, if properly constructed and based on actual results, may be made to apply to the middle diameters of logs, provided the length to which it applies be so limited as to keep within reasonable bounds the errors due to the fact that the losses and gains in board values on the small and large ends do not compensate each other as they do in the cubical volume.

The proposed log-rule is of this character, and the equation for it is:

$$B = \frac{L}{16}\left(\frac{3}{4}\,D^2 - 2D\right).$$

Description of the Study upon which the Rule is Based

Having discussed the theory and drawn definite conclusions therefrom, it remains simply to review the data upon which these conclusions are based.

The measurements were conducted for the Forest Service, in the summer of 1902, by the writer and two assistants, in the more important sawmills then operating in Maine.

In order to eliminate variable factors as much as possible, only straight logs, free from any defects which might influence the quantity of the product, were used. Moreover, only logs which were sawed into boards were of value for the purpose of the study. Since most of the spruce logs were

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turned into "dimension sizes," this fact alone greatly limited the number of serviceable logs. Most of the white pine, however, was sawed into boards, and this species, therefore, furnished the bulk of the data obtained. One exception was that of hemlock sawed into boards at the gang-saw Mill C. Nevertheless, about a thousand spruce logs were measured which were cut into dimension sizes. These figures have been kept separate from the others, and have been worked up into two general classes, consisting of all material 3 inches or less in thickness and all that were over 3 inches. These results, after grouping and averaging, are given in Table IV, for the sake of showing in a general way what is being actually obtained from logs in this form of timber; but the figures are necessarily of little value for a scientific study.

The actual measurements were made in the following manner: One man was stationed on the deck of the mill and two men at the tail, usually near the marker. A string was stretched overhead as a signal from the deck to the tail. The man on the deck measured the log and as soon as it struck the saw, gave a signal to the other men. When the last board fell from the saw another signal was given. In this manner the tally-men were enabled to keep track of all pieces which came from each log independently. Those familiar with the operation of large sawmills will appreciate the difficulty encountered in measuring and keeping track of all the pieces belonging to each respective log during the noise and rush of work in the mill. The measurements of each log were entered consecutively upon printed forms, prepared for the purpose, and thus the separate records were afterwards tallied. The measurements taken of the log on the deck of the mill before sawing were the two diameters at right angles at each end and at the middle, inside and outside the bark, and the length. The diameters were read to the nearest tenth of an inch. After sawing, the width, length, and exact thickness of each piece were recorded. The thickness was found to be most

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accurately determined by a measurement of the saw-kerf and a knowledge of the amount of "set" given on the carriage for each cut.

As a rule, no two mills sawed boards of the same thickness, and the thickness was seldom an exact inch. It was, therefore, necessary, before comparing the final results, to properly reduce them to what they would have been had exact inch boards been produced and with the same saw-kerf in all cases. Thus, suppose that the boards obtained were actually $\frac{31}{32}$-inch thick, and the kerf $\frac{5}{32}$-inch. Then the coefficient by which the results (counted as inch boards) should be multiplied to convert them into the values which would have been obtained had the logs been sawed into exact inch boards with a $\frac{3}{16}$-inch kerf is simply

$$\left(\frac{31}{32} + \frac{5}{32}\right) \div 1\,\frac{3}{16} = 0.9474.$$

This conversion factor is, of course, not strictly correct, except for squared timber; but the error in applying it to round timber is inappreciable. In order to determine exactly what this amounted to, measurements were made on geometrical drawings, with the following results, assuming the log to be "slash-sawed" and the narrowest board not less than 3 inches wide:

Diameter 14 inches	Reckoning to nearest full inch in width	Reckoning to nearest ½ inch in width
Reducing 1 $\frac{1}{16}$ inch boards	$\frac{8}{10}$ of 1%	$\frac{8}{10}$ of 1%
Reducing $\frac{31}{32}$ inch boards	$\frac{8}{10}$ of 1%	0 of 1%

The error is expressed in per cent. of the actual value in exact inch boards.

A correction of this kind has been applied wherever necessary in the following tables and curves, except that in case of the rotary-saw Mill D, the correction has been made to a ¼-inch kerf. The measurements from each log were first grouped, averaged, plotted on cross-section paper, and the points harmonized by curves. The final results thus obtained, after applying the correction factor, are given in

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the following curves and tables. In each case the logs have been grouped both by the small end and by the middle diameters, and each group was worked up independently. In the diagrams, the New Hampshire Rule is shown in dotted lines for the logs grouped according to middle diameters, and the corrected Holland Rule for those grouped by the small ends.

The first three diagrams of curves Figs. 2 to 4 are reproduced to illustrate how the final curves were derived and to show how the original data fall in line.

Description of the Mills

Besides the thickness of the boards, size of saw-kerf and method of sawing, all of which were allowed for in the calculations, there are other factors inherent to the different mills, such as methods of trimming and edging, amount of slabbing, width of narrowest board, and the general efficiency in the operation of the plant, all of which influence the output to a considerable degree. It is necessary, therefore, to have a complete knowledge of these factors for each mill before the results can be used intelligently. The term "mill," as here used, strictly speaking signifies "method of sawing," for Mills A and D were in the same building and A and E were on the same saw.

Mill A.—This was a 9-inch band saw, single cut, with $\frac{8}{16}$-inch kerf. Thickness of boards, $1\frac{1}{16}$ inch. The method of sawing here was for speed rather than for maximum output. The logs were "slash-sawed" in this case, or sawed "alive," as it is called. Laths, fence pickets, and broom-handle stock were made from the waste; the rest was used for fuel. Rotary gang edgers and uniform length cut-offs were used. The narrowest boards were 3 inches wide. The carriage was operated by a "shot-gun" feed and had a taper lever. Slabbing was medium heavy, and no time was spared on unnecessary adjustments. The average output was rated at 58,000 feet per day of $11\frac{1}{2}$ hours.

Mill B.—Band saw, single cut, with a kerf of $\frac{1}{8}$ to $\frac{5}{32}$ inch. Thickness of boards, $\frac{8}{8}\frac{1}{2}$ inch. Width of narrow-

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est board, 3 inches. Logs were sawed "around" or "squared on the saw," a method by which the maximum advantage is obtained from the rise in taper. The method of sawing was for the greatest possible output in boards. A single saw edger was used and the boards were trimmed individually in random lengths. The carriage was operated by a twin engine and cable. The average output was rated as 39,000 feet per day of 11½ hours.

Mill C.—Reciprocating gang saw of the gate type, with 18 to 20 blades, making 170 to 180 complete strokes per minute. The blades were 5½ inches in width and had a kerf of $\frac{5}{32}$ inch. Hemlock logs were made into boards 1 inch thick, which were necessarily sawed "alive," or "slashed." A parallel rotary edger was used. The average capacity of this saw was rated as 40,000 feet per day of 11½ hours.

Mill D.—This was a 52-inch solid-plate, rotary saw, with a kerf of $\frac{5}{16}$ inch. It was in the same building as Mill A and the local conditions were therefore the same. Logs were "slash-sawed." The average output of this saw was rated as 40,000 feet per day. Thickness of boards $1\frac{3}{32}$ inch. The results from this mill were reduced for a saw kerf of ¼ inch rotary, instead of $\frac{3}{16}$ as in the other cases.

Mill E.—This was the same saw as Mill B, the only difference being that these logs were "slash-sawed" instead of being sawed "around," as in B.

As only dimension sizes were being sawed at the two other mills where measurements were taken, it will be unnecessary to describe these here. A resaw was not used in any of these cases.

Examination of the five cases given above will show an excellent series of examples for comparison. A represents the average commercial practice, with rapid sawing and utilization of the waste; B, an example of the maximum obtainable output on a band saw; C, a distinctly different method by reciprocating gang saw; D, a rotary for rapid sawing; and E, a direct comparison with B, showing the advantage in sawing "around" as compared with "slash"

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sawing. A comparison of Mills B and D, which were both in the same building, all other conditions being alike, shows very well the difference between a band saw of $\frac{3}{16}$-inch kerf and a rotary of ¼-inch kerf (the results having been converted for a ¼-inch kerf in the latter case).

Comparison of Sawing "Around" and "Slashing"

Comparison of cases B and E, Tables 8 and 14, shows the following advantage in sawing "around" over "slash" sawing in per cent. of the latter figure:

Small end diameter inside bark	Length in feet	
	16	20
6	15%	22%
7	14	18
8	13	15
9	12	13
10	11	11
11	9	10
12	6	7
13	4	6

The difference is seen to decrease as the log increases in diameter, and for logs under 12 or 13 inches at the small end it is of considerable importance.

Influence of Bends upon Quantity of Product

The influence of a slight bend in the log upon the amount of product was also studied. Forty-four logs of various sizes which had no other defect than a slight bend were measured. The amount of bend was estimated as the greatest distance the surface of the log near the middle would be from the floor at any time as the log is rolled upon a level floor. The amount of deflection of its center line would have been a more logical figure, but was impracticable to obtain. The amount of bend as thus estimated varied from 1 to 5 inches, averaging about 2 inches. The results were compared, log for log, with the values from

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the corresponding curves, and the differences were recorded. These differences were then averaged, and the percentage of loss was figured from the averages. No relation could be determined from so few data between the amount of bend and the percentage of loss, but the result is sufficiently conclusive to say that a bend of 1 to 3 inches in logs less than 18 feet long causes a loss of approximately 3.5 per cent. in the amount of sawed lumber.

Before leaving the subject, it should be remarked that the amount of saw timber obtained from the log depends largely on local circumstances. The question of the amount which *can be* sawed from a given log is a totally different matter from the question of what *is* cut in actual practice. While wood in the form of squared lumber is more valuable than wood cut up into laths, etc., yet considerations of economy in squaring up the smaller pieces may lead to their conversion into by-products rather than into lumber. The expense of running the log through the saw an extra time, for the sake of cutting another small board from the slab, may overbalance the difference in the value of the board over that of the by-products into which it could be converted if left in the slab. Thus heavy slabbing is often necessary as an economy. It is the part of the skillful sawyer to understand the relative importance of the methods of sawing and to cut his log in the most economical manner, whether he gets the maximum product in squared lumber or not.

The following are the complete figures obtained from this study, some abstracts from which were given by Mr. E. A. Ziegler in his article on "The Standardizing of Log Measures" in the foregoing number of the PROCEEDINGS, Tables I and II.

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TABLE I

PROPOSED BOARD-FOOT LOG-RULE FOR LONG LOGS, APPLICABLE TO THE MIDDLE DIAMETER INSIDE THE BARK. LOGS OVER 24 FEET ARE TO BE SCALED AS TWO LOGS, OVER 48 FEET AS THREE LOGS, ETC. DESIGNED FOR COMMON BAND-SAW PRACTICE, $\frac{3}{16}$-INCH KERF, "SLASH" SAWING AND RAPID SPEED, MEDIUM HEAVY SLABBING. FORMULA: $B=L/16\,(\frac{3}{4}\,D^2-2D)$.

Middle Diameters Inside Bark	Length in Feet																
Inches	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
4	*2.*	2	2.5	3	*3.*	3	*3.5*	4	*4*	4	*4.5*	5	*5.*	5	*5.5*	6	*6.*
5	*4.5*	5	6.	6	7.	7	8.	8	*9*	10	10.	11	11.	12	12.	13	*13.5*
6	*7.5*	8	9.	10	11.	12	13.	14	*15*	16	17.	18	19.	20	21.	22	*22.5*
7	*11.5*	13	14.	16	17.	19	20.	22	*23*	24	26.	27	29.	30	32.	33	*34.5*
8	*16.*	*18*	*20.*	*22*	*24.*	*26*	*28.*	*30*	*32*	*34*	*36.*	*38*	*40.*	*42*	*44.*	*46*	*48.*
9	*21.5*	24	27.	30	32.	35	38.	40	*43*	46	48.	51	54.	56	59.	62	*64.5*
10	*27.5*	31	34.	38	41.	45	48.	52	*55*	58	62.	65	69.	72	76.	79	*82.5*
11	*34.5*	39	43.	47	52.	56	60.	65	*69*	73	78.	82	86.	91	95.	99	*103.5*
12	*42.*	47	*52.5*	58	*63.*	68	*73.5*	79	*84*	89	*94.5*	100	*105.*	110	*115.5*	121	*126.*
13	*50.5*	57	63.	69	76.	82	88.	95	*101*	107	114.	120	126.	133	139.	145	*151.5*
14	*59.5*	67	74.	82	89.	97	104.	112	*119*	126	134.	141	149.	156	164.	171	*178.5*
15	*69.5*	78	87.	96	104.	113	122.	130	*139*	148	156.	165	174.	182	191.	200	*208.5*
16	*80.*	*90*	*100.*	*110*	*120.*	*130*	*140.*	*150*	*160*	*170*	*180.*	*190*	*200.*	*210*	*220.*	*230*	*240.*
17	*91.5*	103	114.	126	137.	149	160.	172	*183*	194	206.	217	229.	240	252.	263	*274.5*
18	*104.5*	117	131.	143	157.	170	183.	196	*209*	222	235.	248	261.	274	287.	300	*313.5*
19	*117.5*	132	147.	162	176.	191	206.	220	*235*	250	264.	279	294.	308	323.	338	*352.5*
20	*131.*	147	164.	180	*196.5*	213	229.	246	*262*	278	295.	311	*327.5*	344	360.	377	*393.*
21	*145.5*	164	182.	200	218.	236	255.	273	*291*	309	327.	346	364.	382	400.	418	*436.5*
22	*160.5*	180	201.	221	241.	261	281.	301	*321*	341	361.	381	401.	421	441.	461	*481.5*
23	*176.5*	199	221.	243	265.	287	309.	331	*353*	375	397.	419	441.	463	485.	507	*529.5*
24	*192.*	*216*	*240.*	*264*	*288.*	*312*	*336.*	*360*	*384*	*408*	*432.*	*456*	*480.*	*504*	*528.*	*552*	*576.*
25	*209.5*	236	262.	288	314.	340	367.	393	419	445	471.	498	524.	550	576.	602	*628.5*
26	*227.5*	256	284.	313	341.	370	398.	427	*455*	483	512.	540	569.	597	626.	654	*682.5*
27	*246.5*	277	308.	339	370.	401	431.	462	493	524	555.	585	616.	647	678.	709	*739.5*
28	*266.*	299	*332.5*	366	*399.*	432	*465.5*	499	*532*	565	*598.5*	632	*665.*	698	*731.5*	765	*798.*
29	*286.5*	322	358.	394	430.	466	501.	537	573	609	645.	680	716.	752	788.	824	*859.5*
30	*307.5*	346	384.	423	461.	500	538.	577	*615*	653	692.	730	769.	807	846.	884	*922.5*
31	*329.5*	372	412.	453	494.	535	577.	618	659	700	741.	783	824.	865	906.	947	*988.5*
32	*352.*	*396*	*440.*	*484*	*528.*	*572*	*616.*	*660*	*704*	*748*	*792.*	*836*	*880.*	*924*	*968.*	*1012*	*1056.*

(Figures in italics are exact; others are rounded off to nearest integral number.)

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TABLE II

COMPARISON OF THE PROPOSED BOARD FOOT LOG RULE B=L/16 ($\frac{1}{4}D^2-2D$) WITH PRODUCT OF SEVERAL MILLS AND RATIOS OF CUBIC CONTENTS TO PRODUCT IN BOARD FEET, FOR 16 FOOT LOGS, GROUPED BY MIDDLE DIAMETERS. (CORRECTED FOR EXACT INCH EQUIVALENT AND $\frac{3}{16}$ INCH KERF FOR BAND, $\frac{1}{4}$ INCH FOR ROTARY)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Middle Diameter Inside Bark	Actual Volume of Logs	New Rule ($\frac{1}{4}D^2-2D$)	Actual Saw Cut at Mills in Board Feet				Ratios of *Actual Cubic Feet* 1000 Board Feet					Some Ratios for Cylindrical Logs with no Taper. (Based on 10 ft. Logs Grouped Small End Diameters)			
			A	B	C	D									
Inches	Cu. Ft.		Band Slash	Band Around	Gang Slash	Rotary Slash	Rule	A	B	C	D	A	B	C	D
4	1.40	4	..	..	..	..	300	...	...	...	...	...	...	...	...
5	2.18	9	..	..	..	..	242	...	...	...	...	...	...	...	...
6	3.14	15	13	22	21	13	209	242	143	149	242	151	115	140	196
7	4.82	23	21	32	30	20	205	225	147	157	236	148	111	134	178
8	5.59	32	31	43	40	28	175	180	130	140	200	145	112	129	166
9	7.07	43	42	56	51	37	165	168	126	138	191	138	113	130	158
10	8.73	55	55	69	63	48	158	158	126	138	182	136	111	133	155
11	10.56	69	69	83	75	62	153	153	127	141	170	135	114	135	153
12	12.57	84	84	99	89	77	150	150	127	141	163	133	115	135	148
13	14.75	101	101	116	103	94	146	146	127	143	157	130	117	135	146
14	17.10	119	120	135	119	114	144	143	127	144	150	128	116	135	148
15	19.63	139	140	156	137	...	141	140	126	143	...	127	117	138	...
16	22.34	160	161	178	156	...	140	139	125	143	...	125	116	138	...
17	25.22	183	184	203	177	...	138	137	124	143	...	123	117	137	...
18	28.27	209	208	229	201	...	135	136	124	141	...	122	115	136	...
19	31.50	235	235	258	228	...	134	134	122	138	...	120	114	135	...
20	34.91	262	262	289	257	...	133	133	121	136	...	119	113	132	...
21	38.48	291	292	321	289	...	132	132	120	133	...	118	111	130	...
22	42.24	321	321	356	323	...	131	131	119	131	...	117	110	127	...
23	46.16	353	351	...	...	...	131	131	...	...	...	...	109	...	...
24	50.27	384	381	...	...	...	131	132	...	...	...	...	106	...	...

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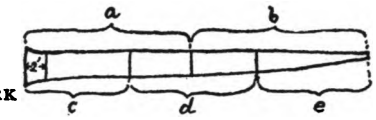
TABLE III

Measurements of Logs at Corbin Park



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Log No.	Diameter Inside Bark, inches							Length of Sections in feet					Volumes in Cubic Feet							Volumes based on middle diameter, only		Shape of Log
	Butt	2 feet from butt	⅓ *l*	Middle	⅔ *l*	Top	Total	*a* half	*b* half	*c* third	*d* third	*e* third	*a*	*b*	(*a*+*b*) Total	*c*	*d*	*e*	(*c*+*d*+*e*) Total	Total	of *d*	
Spruce																						
1	20.7	18.0	15.3	14.6	12.7	10.6	39	20	19	13	13	13	30.5	16.8	47.3	20.9	14.0	9.7	44.6	45.3	15.1	Knotty, straight
2	14.3	×	10.3	8.7	7.8	5.0	46	23	23	15	16	15	17.5	6.4	23.9	12.7	7.3	3.5	23.5	18.8+	6.7	Even, straight
3	10.1	9.0	8.0	7.4	6.7	5.0	38	19	19	13	13	12	7.3	4.2	11.5	5.3	3.9	2.3	11.5	11.4	3.9	Very even, straight
4	9.8	9.0	7.8	7.2	6.0	4.0	46	23	23	15	16	15	8.5	4.3	12.8	6.0	4.2	2.2	12.4	12.9	4.5	Very even, straight
5	13.6	10.6	9.2	8.4	7.8	6.0	42	21	21	14	14	14	11.0	6.1	17.1	8.0	5.5	3.7	17.2	16.0	5.3	Even, straight
6	13.6	×	10.2	9.0	9.1	3.9	48	24	24	16	16	16	17.4	6.2	23.6	12.6	8.2	4.2	25.0	21.1	7.0	Knotty, crooked
7	15.2	14.0	11.9	11.0	7.2	5.6	48	24	24	16	16	16	22.0	10.7	32.7	15.2	8.4	3.6	27.2	34.6	11.5	Knotty, even, straight
8	8.2	×	6.6	5.9	5.0	3.3	36	18	18	12	12	12	5.0	2.3	7.3	3.7	2.3	1.2	7.2	6.8	2.3	Even, straight
9	11.9	×	9.7	8.6	7.4	3.8	48	24	24	16	16	16	14.0	5.8	19.8	10.2	6.5	3.0	19.7	19.2	6.4	Even, straight
10	17.4	16.0	12.0	10.2	8.4	4.0	50	25	25	17	16	17	25.7	8.3	34.0	19.4	9.3	4.0	32.7	28.5	9.1	Very knotty, straight
11	7.0	×	5.9	5.2	4.9	3.7	42	21	21	14	14	14	4.4	2.3	6.7	3.2	2.2	1.4	6.8	6.3	2.1	Fairly even, straight
12	19.5	16.5	12.6	11.1	8.6	5.9	48	24	24	16	16	16	27.2	10.3	37.5	20.0	10.2	4.7	34.9	32.2	10.7	Very knotty, straight
13	16.5	14.0	12.2	11.3	9.4	6.8	40	20	20	13	14	13	18.5	9.5	28.0	12.9	9.0	4.7	26.6	28.0	9.8	Knotty, straight

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TABLE III—*Concluded*

MEASUREMENTS OF LOGS AT CORBIN PARK

Log No.	Diameter Inside Bark, inches						Total	Length of Sections in feet					Volume in Cubic Feet							Volumes based on middle diameter, only		Shape of Log
	Butt	2 feet from butt	⅓ *l*	Middle	⅔ *l*	Top		*a* half	*b* half	*c* third	*d* third	*e* third	*a*	*b*	(*a*+*b*) Total	*c*	*d*	*e*	(*c*+*d*+*e*) Total	Total	of *d*	
Balsam																						
14	9.6	×	8.3	6.9	6.2	4.0	40	20	20	13	14	13	7.6	3.5	11.1	5.7	4.1	2.0	11.8	10.4	3.6	Very even, clear
15	11.0	10.2	8.0	7.3	6.5	3.8	38	19	19	13	12	13	8.5	3.5	12.0	6.3	3.5	2.0	11.8	11.0	3.5	Very even, clear
16	9.0	8.6	7.6	7.2	6.7	5.0	34	17	17	11	12	11	5.9	3.6	9.5	4.0	3.3	2.1	9.4	9.5	3.4	Very even, clear
17	13.7	12.2	10.6	9.3	7.9	3.6	46	23	23	15	16	15	15.3	6.2	21.5	11.1	7.6	3.1	21.8	21.6	7.5	Very straight
18	9.8	×	7.7	7.1	6.2	4.1	40	20	20	13	12	13	7.9	3.6	11.5	5.5	3.2	2.0	10.7	10.8	3.2	Even, straight
19	11.5	10.4	8.6	8.0	7.1	5.5	46	23	23	15	16	15	11.2	5.9	17.1	7.7	5.4	3.2	16.3	16.1	5.6	Even, straight
20	11.4	10.0	7.8	7.7	6.2	4.5	38	19	19	13	12	13	8.5	4.1	12.6	6.0	3.2	2.1	11.3	12.2	3.8	Even, straight
21	10.4	10.0	8.2	7.8	7.1	4.6	40	20	20	13	14	13	9.0	4.0	13.0	6.1	4.5	2.5	13.1	13.2	4.6	Even, straight
22	10.0	×	8.7	8.2	7.6	5.1	42	21	21	14	14	14	9.5	5.4	14.9	6.7	5.0	3.1	14.8	15.5	5.2	Even, straight
23	7.1	6.6	....	5.7	....	4.9	20	10	10	..	..	..	2.2	1.5	3.7	....	....	...	....	3.6	...	Even, straight, clear
White Pine																						
24	13.1	11.6	9.8	9.0	7.8	4.7	46	23	23	15	16	15	13.9	6.5	20.4	9.8	6.8	3.4	20.0	20.2	7.0+	Knotty top
25	17.5	13.7	11.6	10.7	9.1	5.2	42	21	21	14	14	14	18.3	8.1	26.4	13.2	8.3	4.2	25.7	26.0	8.7	Very knotty
26	17.6	16.2	....	13.8	....	12.1	23	12	11	..	..	..	15.3	10.1	25.4	....	....	...	....	23.9	...	Knotty
Hemlock																						
27	12.0	×	....	9.2	....	4.4	28	14	14	..	..	..	8.7	4.0	12.7	....	....	...	....	12.9	...	Knotty
28	14.0	14.0	....	12.8	....	10.7	23	12	11	..	..	..	11.9	8.3	20.2	....	....	...	....	20.5	...	Knotty top
29	11.8	11.8	....	10.1	....	9.6	24	12	12	..	..	..	8.1	6.4	14.5	....	....	...	....	13.4	...	Clear
30	9.3	×	....	7.5	....	4.2	23	12	11	..	..	..	4.7	2.2	8.9	....	....	...	....	7.1	...	Even, knotty
31	10.6	×	....	8.5	....	4.3	27	14	13	..	..	..	7.0	3.2	10.2	....	....	...	....	10.5	...	Top knotty and tapered
32	12.5	12.1	....	9.0	....	4.7	25	13	12	..	..	..	8.5	3.4	11.9	....	....	...	....	11.0	...	Very knotty
33	12.4	12.0	....	9.6	....	4.5	28	14	14	..	..	..	9.4	4.3	13.7	....	....	...	....	14.0	...	Even, knotty
34	21.4	20.0	....	16.3	....	16.0	22	11	11	..	..	..	21.0	15.7	36.7	....	....	...	....	31.9	...	Clear seam near butt

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TABLE IV

Dimension Sizes. Nominal Product in Board Feet

Mill and Species	Length, Class, feet	Three inches and under in Thickness							Four inches and over in Thickness						
		Average Values						No. of Logs Averaged	Average Values						No. of Logs Averaged
		Length of Log, feet	Diam. small end, inches	Diam. middle, inches	Output, board ft.	Excess of Holland Rule			Length of Log, feet	Diam. small end, inches	Diam. middle, inches	Output, board ft.	Excess of Holland Rule		
						board ft.	per cent.						board ft.	per cent.	
A Band Spruce	16 & less	15	13.4	14.2	130	8	7.	22	14	9.0	10.0	52	1	2.	6
	17–20	19	12.8	14.1	175	31	22.	45	19	9.4	10.6	86	10	13.	13
	21–24	23	13.7	15.0	241	46	24.	51	23	8.4	9.8	76	8	12.	10
	25–28	27	14.1	15.8	295	49	20.	29	27	8.5	9.9	100	19	23.	9
	29 & over	31	13.3	14.8	297	49	20.	14	34	9.4	11.2	166	27	19.	37
								161							75
B Band Spruce	16 & less	14	10.0	10.8	81	16	25.	20	16	10.1	10.5	81	13	19.	1
	17–20	19	9.9	10.9	98	20	26.	11	19	8.1	9.1	66	17	35.	2
	21–24	24	8.6	9.8	107	33	45.	6	..	..	...	...	...	...	..
	25–28	26	7.4	7.9	65	15	30.	1	27	8.7	10.0	97	12	14.	2
	29 & over	32	7.8	9.9	122	10	9.	1	..	..	...	...	...	...	..
								39							5
B Band Hemlock	16 & less	14	11.8	12.5	98	6	7.	48	14	12.0	12.9	102	8	9.	7
	17–20	19	12.0	13.0	136	6	5.	10	19	13.6	14.3	186	11	6.	3
	21–24	..	....	....	....	...	...	..	23	11.0	12.4	140	12	9.	4
	25–28	26	13.3	14.2	264	69	35.	1	27	11.0	12.0	180	33	22.	2
	29 & over	..	....	....	....	...	...	..	30	8.3	9.5	101	19	23.	1
								59							17

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C Gang Spruce	16 & less	15	10.5	10.9	69	4	6.	52	14	9.2	10.0	54	−2	−4.	05
	17–20	19	9.9	10.6	88	14	19.	27	20	7.5	8.5	51	3	6.	19
	21–24	23	9.7	11.0	115	18	19.	48	24	7.6	8.8	67	8	14.	0
	25–28	27	9.3	10.6	112	12	12.	23	26	8.3	9.6	83	3	4.	12
	29 & over	30	9.2	11.0	132	14	12.	9	31	8.8	10.7	91	−14	−13.	
								159							36
D Rotary Spruce	16 & less	14	10.1	11.0	64	−2	−3.	75	15	8.4	9.4	46	1	2.	52
	17–20	19	10.5	11.6	99	3	3.	25	19	9.0	10.3	73	6	9.	37
	21–24	23	11.8	12.9	166	19	13.	6	22	8.3	9.5	70	7	11.	21
	25–28	26	9.6	11.2	117	12	11.	8	27	9.0	10.3	107	16	18.	11
	29 & over	30	8.1	10.3	86	4	5.	1	31	9.2	10.7	129	20	18.	11
								115							132
F Band Spruce	16 & less	12	8.8	9.6	48	4	9.	27	16	8.9	9.9	63	11	21.	4
	17–20	19	9.9	11.1	102	15	17.	6	..	..	...	...	...	....	..
	21–24	23	8.8	10.0	93	18	24.	12	23	9.2	10.6	110	23	26.	6
	25–28	27	8.8	10.2	113	25	28.	24	28	9.2	10.6	155	53	52.	4
	29 & over	31	9.8	11.6	158	26	20.	7	33	8.2	9.9	133	23	21.	5
								76							19
G Rotary Spruce	16 & less	14	10.1	11.5	70	4	6.	4	12	8.2	9.1	32	−1	−3.	1
	17–20	20	13.3	14.3	156	1	2.	15	20	8.5	9.8	70	5	8.	1
	21–24	22	11.2	12.5	123	−1	−1.	5	23	13.3	13.9	193	1	½.	2
	25–28	26	9.6	12.4	125	14	13.	1	..	..	...	...	. .	...	..
	29 & over	..	....	....	....	...	...	..	..	..	...	...	...	...	..
								25							4

NOTE.—The values for "Excess of Holland Rule" are figured for each individual log separately and the results averaged to obtain the figures in the table.

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TABLE V

THE HOLLAND RULE CORRECTED BY CURVES. FOR LENGTHS 10 TO 28 FEET AND DIAMETERS 6 TO 24 INCHES

Small-End Diameters Inside Bark	Length in Feet																		
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
6	13	14	15	16	17	18	20	21	22	23	25	26	27	28	29	31	32	33	35
7	19	21	23	25	26	28	30	32	34	36	38	40	42	44	45	47	49	51	53
8	26	29	31	34	36	39	42	45	47	50	52	55	58	61	63	65	67	70	73
9	34	37	41	44	47	50	54	57	61	64	68	71	75	78	82	85	88	91	95
10	43	47	51	55	59	63	68	72	76	80	85	89	93	97	102	106	110	114	119
11	52	57	62	67	73	78	83	88	93	98	104	109	114	119	125	130	135	140	145
12	62	68	75	81	87	93	99	105	112	118	124	130	136	142	149	155	162	168	174
13	73	80	88	95	102	109	117	124	132	139	146	153	161	168	176	183	190	197	205
14	85	93	102	110	119	127	136	144	153	161	170	178	187	195	204	212	221	229	238
15	98	108	118	127	137	147	157	166	176	186	196	206	216	225	235	245	255	265	275
16	112	123	135	146	157	168	180	199	202	213	225	236	247	258	270	280	292	303	315
17	128	141	154	166	179	192	205	218	231	243	256	269	282	295	307	320	333	346	359
18	145	160	175	189	204	218	233	247	262	277	292	306	321	335	350	364	379	393	408
19	164	180	197	213	230	246	263	279	296	312	329	345	362	378	395	411	427	443	460
20	184	202	221	239	258	276	295	313	332	350	369	387	406	424	443	461	479	497	516
21	205	226	247	267	288	308	329	349	370	390	411	431	452	473	494	514	535	555	576
22	228	251	274	296	319	341	364	387	410	432	455	478	501	524	547	570	593	615	638
23	252	277	302	327	352	377	403	428	452	478	503	528	554	579	604	629	654	679	705
24	277	304	332	359	387	415	443	470	498	525	553	581	609	636	664	691	719	747	775

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TABLE VI

MILL NO. A. BAND SAW. SAWED ALIVE. GROUPED BY SMALL-END DIAMETERS. REDUCED TO EXACT INCH-BOARD EQUIVALENT

Small-End Diameters Inside Bark	Length in Feet							
	10	12	14	16	18	20	22	24
6	13	15	17	20	22	24	27	29
7	18	22	25	29	33	36	39	43
8	24	29	34	39	44	49	54	59
9	32	38	44	51	58	64	71	77
10	40	48	56	64	72	80	88	97
11	49	59	69	79	89	99	109	119
12	59	71	83	95	107	119	131	143
13	71	85	99	113	127	141	155	170
14	83	100	116	133	149	165	182	199
15	97	116	135	154	173	193	212	231
16	112	134	156	178	200	223	245	268
17	128	154	179	205	231	257	283	309
18	145	175	204	233	263	293	322	
19	164	198	232	265	298			
20	183	222	261	299				
21	204	249	295					
22	225	275						

Based on 224 logs.

TABLE VII

MILL NO. A. BAND SAW. SAWED ALIVE. GROUPED BY MIDDLE DIAMETERS. REDUCED TO EXACT INCH-BOARD EQUIVALENT

Middle Diameters Inside Bark	Length in Feet							
	10	12	14	16	18	20	22	24
6	8	10	12	13	15	16	18	19
7	13	16	18	21	24	26	29	32
8	19	23	27	31	35	39	43	46
9	26	32	37	42	47	53	58	63
10	34	41	48	55	62	69	76	83
11	43	52	60	69	78	86	95	104
12	53	63	74	84	95	106	117	127
13	63	76	88	101	114	127	140	153
14	75	90	105	120	135	150	165	180
15	87	104	122	140	158	175	193	210
16	100	120	141	161	182	202	222	242
17	115	138	161	184	207	231	254	277
18	131	157	183	208	235	261	288	315
19	147	176	205	235	264	294	323	352
20	165	198	230	262	295	328	362	395
21	183	219	256	292	329	365		
22	203	242	281	321	361			
23	223	265	308	351				
24	245	290	336	381				

Based on 224 logs.

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TABLE VIII

MILL NO. B. BAND SAW. SQUARED ON THE SAW. GROUPED BY SMALL-END DIAMETERS. REDUCED TO EXACT INCH-BOARD EQUIVALENT

Small-End Diameters Inside Bark	Length in Feet								
	8	10	12	14	16	18	20	22	24
6	13	17	22	26	30	34	39	44	50
7	19	24	29	35	41	47	53	60	67
8	25	32	39	46	53	60	68	76	84
9	31	39	48	57	66	75	84	94	103
10	39	49	59	70	81	91	101	113	124
11	46	58	70	83	96	108	121	134	147
12	54	68	83	97	112	126	141	156	172
13	63	79	96	113	130	147	165	183	200
14	73	92	111	130	149	170	190	211	232
15	83	105	127	149	171	194	218	242	267
16	95	120	145	170	196	223	250	278	306
17	107	135	164	193	222	253	284	317	351
18	121	153	185	218	251	287	323	359	
19	136	172	208	245	282	321	362		
20	153	193	233	274	316	358			
21	171	216	261	306	352				
22	190	240	290	339					
23	211	266	321	376					
24	233	297	352						

Based on 167 logs.

TABLE IX

MILL NO. B. BAND SAW. SQUARED ON THE SAW. GROUPED BY MIDDLE DIAMETERS. REDUCED TO EXACT INCH-BOARD EQUIVALENT

Middle Diameters Inside Bark	Length in Feet								
	8	10	12	14	16	18	20	22	24
6	12	14	17	19	22	23	24	25	27
7	18	21	25	28	32	34	37	39	41
8	23	28	33	38	43	47	51	54	57
9	29	35	42	49	56	61	66	70	75
10	35	43	52	60	69	76	83	89	96
11	42	52	63	73	83	92	101	109	118
12	50	62	75	87	99	110	122	132	143
13	58	72	87	101	116	130	144	157	171
14	67	84	101	118	135	152	169	186	203
15	78	97	117	136	156	176	196	217	238
16	89	111	133	155	178	202	227	252	278
17	100	125	151	177	203	231	260	290	321
18	113	141	170	199	229	262	295	332	370
19	126	158	191	224	258	296	334	377	
20	141	177	213	251	289	331	373		
21	157	197	237	279	321	367			
22	173	217	262	309	356				
23	190	239	288	339					
24	207	261	315	371					

Based on 167 logs.

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TABLE X

MILL NO. C. GANG SAW. INCH BOARDS. HEMLOCK. GROUPED BY SMALL-END DIAMETERS. REDUCED TO EXACT INCH-BOARD EQUIVALENT

Small-End Diameters Inside Bark	Length in Feet					
	10	12	14	16	18	20
6	14	18	21	24	28	31
7	20	25	29	34	38	43
8	27	32	38	43	49	55
9	34	41	48	55	62	69
10	41	50	58	67	75	84
11	49	59	69	80	90	100
12	58	70	82	94	106	119
13	68	82	95	109	124	139
14	79	94	109	126	142	160
15	89	108	126	145	165	185
16	101	122	143	165	188	211
17	115	139	163	187	214	240
18	130	156	184	212	241	271
19	146	176	207	239	271	305
20	165	198	233	268	304	341
21	185	223	261	300	340	382
22	208	249	291	334	378	

Based on 56 logs.

TABLE XI

MILL NO. C. GANG SAW. INCH-BOARDS. HEMLOCK. GROUPED BY MIDDLE DIAMETERS. REDUCED TO EXACT INCH-BOARD EQUIVALENT

Middle Diameters Inside Bark	Length in Feet					
	10	12	14	16	18	20
6	13	16	19	21	24	26
7	19	23	26	30	34	38
8	25	30	35	40	45	51
9	32	38	44	51	58	65
10	39	47	54	63	71	79
11	46	56	65	75	85	94
12	55	66	77	89	99	111
13	64	77	90	103	116	129
14	74	89	104	119	134	149
15	85	102	119	137	154	171
16	97	117	137	156	175	195
17	111	133	155	177	199	222
18	125	150	176	201	226	252
19	142	170	199	228	256	285
20	160	192	224	257	289	321
21	180	216	252	289	325	360
22	201	241	282	323	363	403

Based on 56 logs.

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TABLE XII

MILL NO. D. ROTARY SAW. SAWED ALIVE. GROUPED BY SMALL-END DIAMETERS. REDUCED TO EXACT INCH-BOARD EQUIVALENT

Small-End Diameters Inside Bark	Length in Feet					
	10	12	14	16	18	20
6	10	13	15	18	20	23
7	15	19	22	25	29	33
8	21	26	30	35	40	45
9	28	34	40	46	52	59
10	35	43	51	59	67	76
11	43	53	63	73	83	94
12	53	65	77	89	102	115
13	63	77	92	107	123	
14	72	90	109	127		

Based on 99 logs.

TABLE XIII

MILL NO. D. ROTARY SAW. SAWED ALIVE. GROUPED BY MIDDLE DIAMETERS. REDUCED TO EXACT INCH-BOARD EQUIVALENT

Middle Diameters Inside Bark	Length in Feet					
	10	12	14	16	18	20
6	9	11	12	13	14	15
7	13	16	18	20	22	23
8	19	22	25	28	30	32
9	24	29	33	37	41	44
10	31	37	43	48	53	58
11	38	46	54	62	69	75
12	47	57	67	77	87	96
13	57	69	81	94	107	121
14	68	82	98	114	131	

Based on 99 logs.

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TABLE XIV

MILL NO. E. BAND SAW. SAWED ALIVE. GROUPED BY SMALL-END DIAMETERS. REDUCED TO EXACT INCH-BOARD EQUIVALENT

Small-End Diameters Inside Bark	Length in Feet					
	10	12	14	16	18	20
6	16	19	22	26	29	32
7	21	27	31	36	40	45
8	29	35	41	47	53	59
9	38	45	52	59	66	74
10	46	55	64	73	82	91
11	56	66	77	88	99	110
12	67	80	93	106	119	132
13	78	93	109	125	140	156

Based on 62 logs.

TABLE XV

MILL NO. E. BAND SAW. SAWED ALIVE. GROUPED BY MIDDLE DIAMETERS. REDUCED TO EXACT INCH-BOARD EQUIVALENT

Middle Diameters Inside Bark	Length in Feet					
	10	12	14	16	18	20
6	14	15	16	17	19	20
7	19	22	25	27	29	31
8	26	30	34	37	41	44
9	32	38	44	49	54	59
10	40	48	55	63	70	77
11	49	59	69	79	89	99
12	60	72	85	97	110	
13	72	87	103			
14	81	103				

Based on 62 logs.

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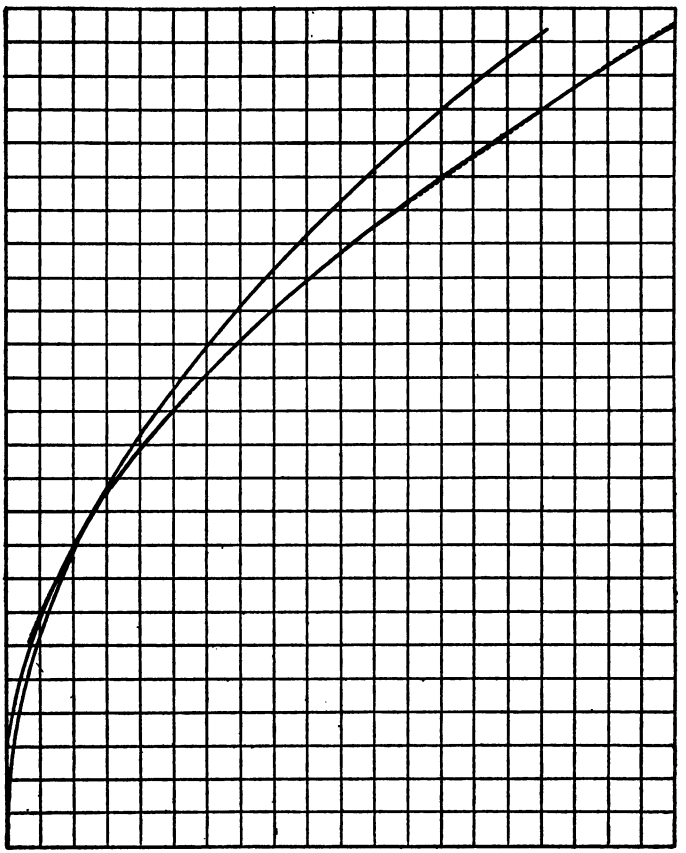

FIGURE 1. Comparison of the saw cut Mill A (dash-line) with Proposed Log Rule (heavy line which almost coincides with the dash-line) and with the New Hampshire Rule for sixteen-foot logs. This shows the difference between a true and a disguised board-foot rule, the New Hampshire being in reality a volume rule.

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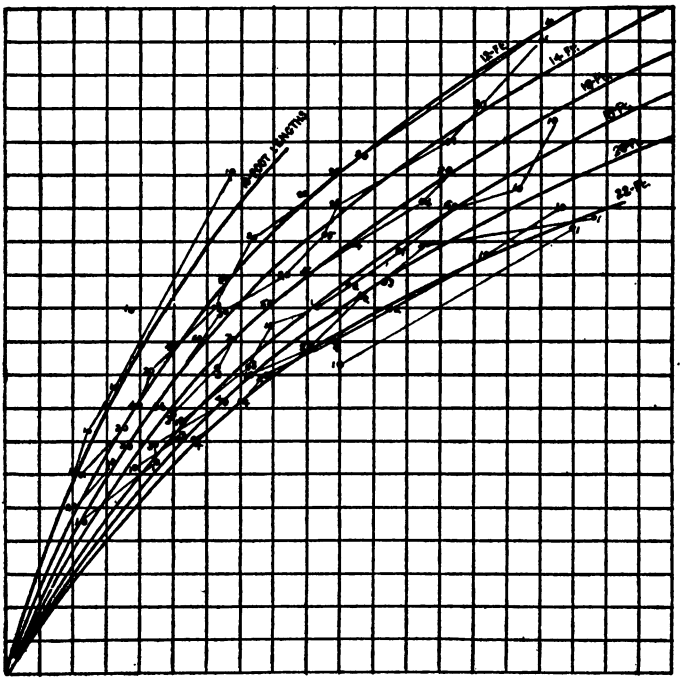

FIGURE 2. First plotting from original data, Mill B. The original averages are shown by the small circles; the numeral signifies the number of logs averaged for each.

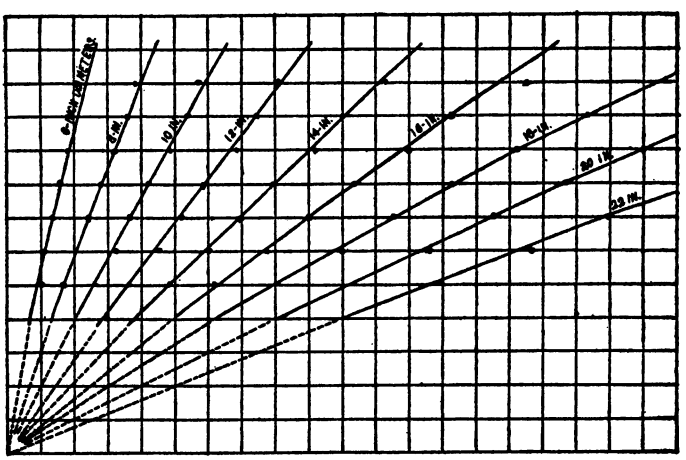

FIGURE 3. Second operation in process of averaging by curves. The small circles are the points obtained from the curves in Figure 2.

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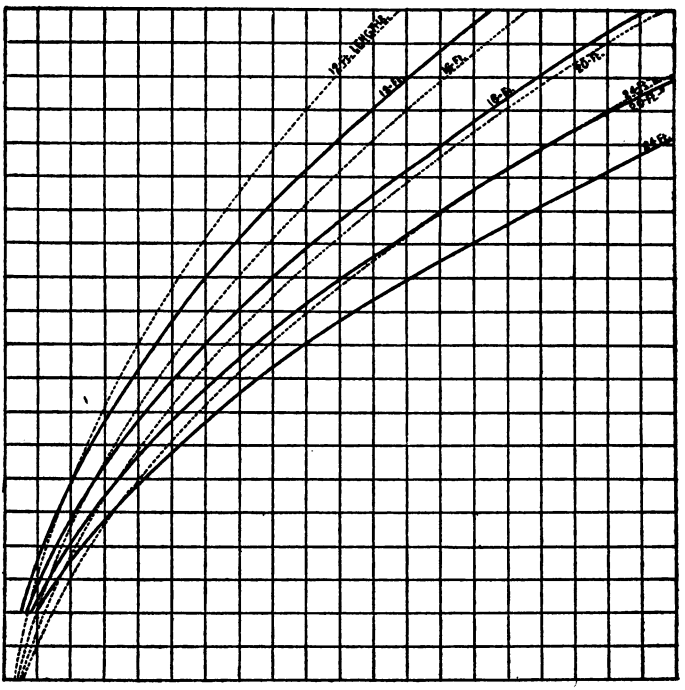

FIGURE 6. Final averaged results from Mill A, grouped by middle diameters. New Hampshire rule indicated in dotted lines.

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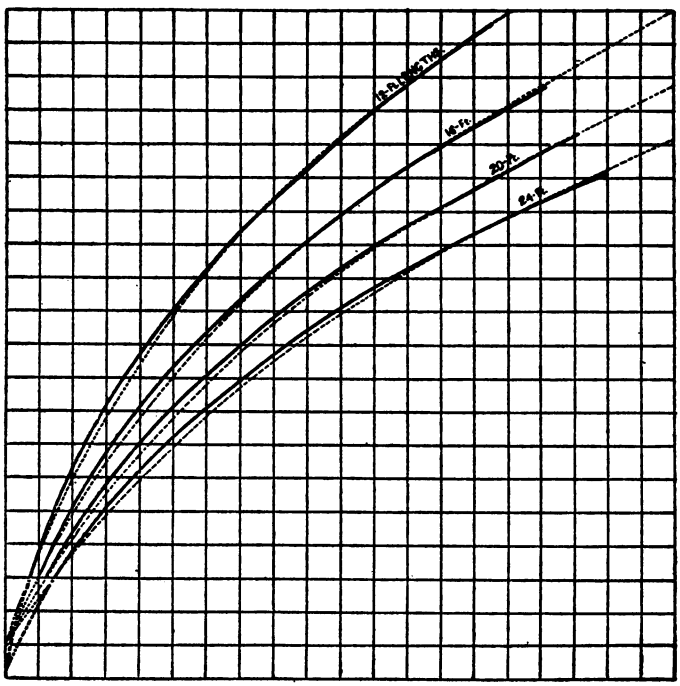

FIGURE 5. Final averaged results from Mill A, grouped by small-end diameters. Holland rule indicated in dotted lines.

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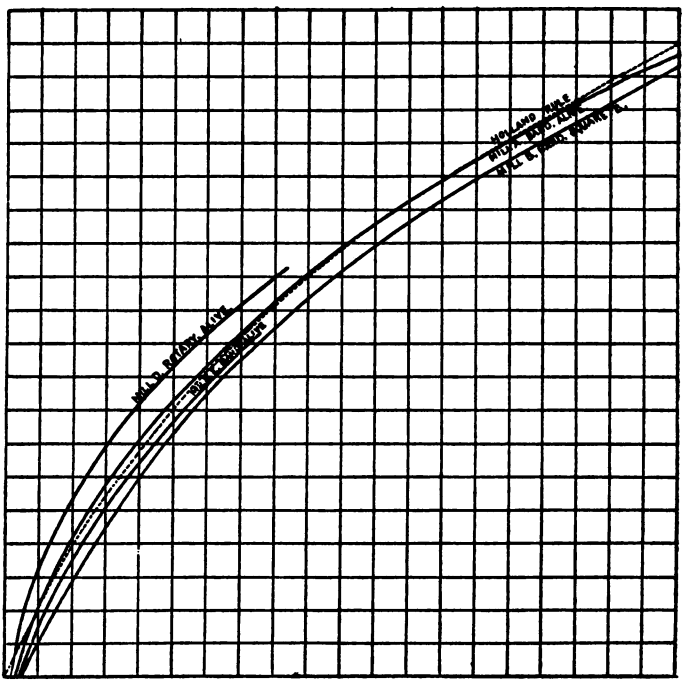

FIGURE 15. Comparison of results from Mills A, B, D, and E for 16-foot logs, grouped by small-end diameters. Holland rule indicated by dotted line.

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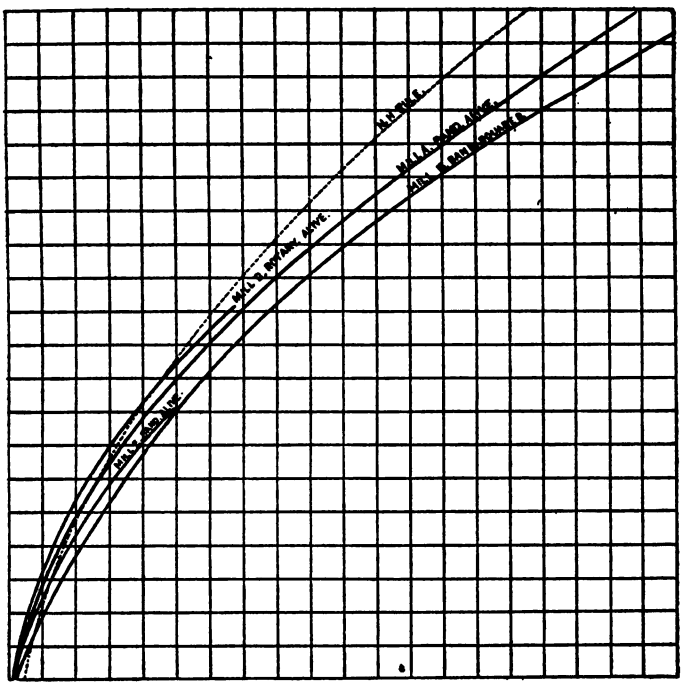

FIGURE 16. Comparison of results from Mills A, B, D, and E, for 16-foot logs, grouped by middle diameters. New Hampshire rule indicated by dotted line.

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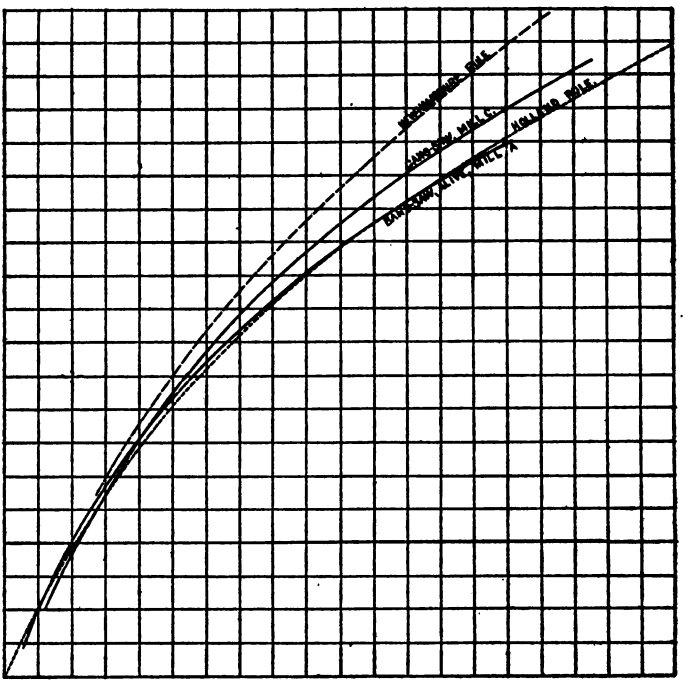

FIGURE 17. Comparison of the results from Mills A and C with the New Hampshire and Holland rules for 16-foot logs, grouped by small-end diameters. In order to show the New Hampshire rule on this plate, an allowance of 0.6 inch in taper is used between the middle and small-end diameters.

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EXPERIMENTS IN SANDHILL PLANTING

CARLOS G. BATES

Contributed

Description of Region

The sandhill region of Nebraska occupies an area of nearly 18,000 square miles, or one-fourth of the area of that large State. Within this area, almost the entire space is occupied by a sand-dune formation, there being only here and there occasional valleys or moors in which the soil is of cretaceous origin. The major portion of the area consists of rounded, sometimes almost conical dunes from fifty to one hundred feet high, which are in some portions united into long, round-topped ridges, with the axes extending west-northwest and east-southeast. The prevailing spring winds, which are still in many localities molding and remodeling these dunes, are from the west or northwest, and are anticyclonic in character, hence lacking in humidity, and extremely desiccating.

The sand of these dunes is sometimes as much as 150 feet deep, and is underlain with a more impervious stratum of cretaceous origin. It has originated in part from the sandy cretaceous layer, which to the northwest is much less eroded and still exists as a high, rocky ridge, known in Nebraska and South Dakota as the "Pine Ridge." The larger portion of the sand, however, is of a coarser character, and has evidently been brought to this region by the waters from the eastern slope of the Rocky Mountains. It is probable that other rivers besides the Niobrara existed, which passed through the region in an easterly direction. The Loup River system, which drains most of the sandhill area at present, is of more local character.

The Platte River, which flows from the Continental Divide in an easterly direction across Nebraska, and the Arkansas River in Kansas are of the same character, and

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are annually adding a deposit of coarse sand to the dunes along their right-hand banks. It may be seen, therefore, that the formation of sand-dunes in the Plains region is still in a young stage, and that the problems of forestry connected with them are of wide importance.

Economically, the Nebraska sandhills are of great importance to the State of Nebraska, but considering their great area, the income derived from them is extremely small. Formerly they were occupied almost entirely by large cattle ranches, separated by miles of unfenced range, which is of such a character that twenty acres are needed for the sustenance of a single animal. The privileges of this free range were greatly abused, so that throughout most of the region the quality of the forage was impaired, and the herbaceous covering of the hills so largely destroyed that the moving of the sand became serious. This condition is now improved, however, on account of the fencing of the individual territories of the many ranch owners, and the consequent desire of each individual to conserve the natural wealth on which his future prosperity depends. The Government control of the range by the Forest Service has had the same beneficial effect, settling all disputes as to the privileges of the range, and directly deciding the number of cattle to be grazed.

Throughout the sandhills there are small areas of agricultural land, which under scientific treatment are gradually becoming more and more profitable. In years of good rainfall they produce abundantly; and even in the driest years they are less likely to fail entirely than are those farm lands in the State which have a heavier (physiologically dry) soil. The greatest mistake in the past has been the cultivation of exposed areas in which the soil was very light and was blown away as soon as the roots of the native vegetation had been destroyed. This error led to the financial ruin of many of the early settlers, and in view of it, recent colonization of the sandhills has been very slow, but it is apparently on a much more stable basis now.

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From the forestry standpoint, the Nebraska sandhills present wonderful possibilities. The sand-dunes are potential forest lands. Grazing upon them is not only second class as regards quality and revenue, but is always likely to lead to wind erosion, with the consequent encroachment of the sand-dunes upon the fertile, agricultural land to the southeast. Agriculture can be carried on only in the most fertile and protected valleys. As a protection to the sandhills for the purposes of water supply, forests are unnecessary, because the very porous nature of the soil prevents any waste of water by run-off. Most of the area drains directly *downward.* The water sinks until it strikes an impervious layer, and appears along the sides of the valleys of the few large streams in the form of permanent springs. The larger streams are very stable, showing no marked flood stage, and only after protracted drought do they decrease appreciably in volume. Even this, however, is not an important consideration, because, within this region, the water can not be used for irrigation.

There is every evidence that the sandhills are adapted to the growing of commercial coniferous forests. Where the sandhills abut upon the Pine Ridge to the northwest, the western yellow yine (*Pinus ponderosa*) has come in, and occasional large specimens are found in soils of the poorest class. The difficulties of reproduction seem only to have retarded its wider spread. In the region where the extensive planting has already been done, the yellow pine does not exist, but its invariable associate, the bear-berry (*Arctostaphylos uva-ursi*), is frequently met with. From time to time, large logs and petrified specimens of both yellow pine and red cedar (*Juniperus scopulorum*) have been unearthed in the immediate region. Prior to the beginning of planting operations, therefore, there was every indication of their ultimate success, and since such problems have been met and conquered in the Old World, the afforestation of the Nebraska sandhills appeals to the forester as a problem worthy of the greatest effort, demanding the most acute application of science, and promising ultimate victory.

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History of Planting

In the year 1902, the federal Bureau of Forestry made a survey of the sandhill region in the Loup River drainage area, laid out a tract of 85,000 acres as a Forest Reserve, and established a forest nursery near the small town of Halsey. This is about forty miles west of the eastern limit of the main tract of hills. The move was made at the instigation of the Secretary of Agriculture, and of Professor Charles E. Bessey, botanist of the University of Nebraska. It had behind it the evidence already mentioned, the success of a moderately large plantation of jack pine (*Pinus divaricata*), made by the Department of Agriculture in 1890 on the ranch of the Bruner Brothers in the northern portion of the hills, and the results of numerous other smaller experiments. The importance of Dr. Bessey's interest in Nebraska forestry, and particularly in the establishment of the Dismal River Forest Reserve, can not be overestimated. Being a close observer of natural phenomena, he has from the outset maintained that the growing of conifers in the Nebraska sandhills is not only practicable, but logical.

The forest nursery at Halsey yielded no stock for planting until the spring of 1904, when there were on hand yearling seedlings of both yellow and jack pines. During the season of 1903, however, there were planted several thousand forest seedlings of jack pine obtained from the woods of Minnesota. Most of these were from four to eight years old, and were sturdy enough to withstand the trials of the first year. A large proportion of them grew well, and are now from six to eight feet high.

Until the spring of 1907, no transplanted stock was produced in the Halsey nursery. Seedlings of one, two, and three years were used at various times, and the immaturity of the trees is undoubtedly in large measure responsible for the numerous losses, sometimes amounting to almost complete failure in the most difficult situations. Since more sturdy and mature stock has been grown, there has been a

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marked increase in the success of field planting. In spite of all precautions, however, the results obtained are not satisfactory. The difficulty is mainly in the unfavorable character of the planting site, but also in the character of the nursery ground.

In this region the precipitation is not heavy, but still of sufficient quantity to support tree growth. It amounts to about nineteen inches per annum. The winter snowfall is light, but the ground is usually moist when planting operations are begun in the spring. The soil sometimes becomes dry before the summer rains begin, about the middle of May. The larger portion of the rain falls between this time and the middle of July. There is then little rainfall until the first of September.

The coarse, porous character of the soil induces but little capillary movement of the moisture upward, but with the water table near the surface this is nearly always sufficient to furnish abundant moisture at a depth of two feet or less. The moisture percentages are, of course, low, but almost all of the water is available for plant growth. On this account, trees are scarcely ever in danger of drought, except in situations where the moisture is taken by the native vegetation. The coarse perennial herbs, including many deep-rooted grasses, have first access to the moisture of the soil, and newly planted trees are at a great disadvantage, especially in the low, protected situations, where the vegetation is most dense.

The winds of the sandhill region are frequently strong, and almost invariably desiccating. The most severe winds occur in the spring, between the time of thawing and the occurrence of the early summer rains. They come from the northwest, and strike the newly planted trees at the time of their greatest susceptibility, and when it is of most vital importance that their water supply should be conserved. The summer winds, from the south, are usually less violent, and have not quite the desiccating power of the westerlies. Only in late summer are they likely to cause damage to

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trees. The winds of both classes probably do much more damage by their mechanical than by their physical effects. As they absorb the moisture of the surface soil, which is frequently very dry withn a few hours after a rain, the coarse sand is drifted over the smooth surfaces, abrasing the stems of the tender trees, and again being deposited in the depressions, frequently covering the trees wholly or in part. The damage to the tree from this source arises partly through the prevention of transpiration, but more largely through the excessive heating of the stem and lower leaves when the sand has been brought to a dangerous temperature by direct insolation. It is especially noticeable that trees on south slopes suffer in this way, while on north slopes, even though deeply covered, they survive for a long period.

While the soil of the sandhills is extremely poor, and contains only small amounts of soluble plant foods, it is believed that there is an abundance of this material for *coniferous* trees. On the other hand, even were moisture conditions more favorable, it would appear to be unwise to attempt to grow *hardwoods* in a soil of this character. The first conclusion is drawn from the fact that the growth of yellow pine and jack pine has not been more rapid in the bottomland situations, where humus and soluble salts collect, than in the poorer soil of the ridges.

The final success of the plantations made to date has been affected not only by those factors which influence the life of the trees during the most crucial period after planting, but also by the action of various animals which have appeared as enemies of the incipient forest. Of these the jack-rabbit and pocket-gopher, among mammals; the sharp-tailed grouse and prairie-hen, among birds; and the grasshopper, among insects, have been most injurious. The loss of trees by girdling and the loss of growth by the nipping of the winter-buds have been considerable. No fungous diseases other than those which might have been contracted in the nursery have as yet appeared to complicate the problem.

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The difficulties of growing a nursery stock suitable for the trying conditions of the sandhills are no less than those encountered in the planting operations. Obviously, in order to insure success under such trying conditions, the most sturdy, vigorous, and thrifty trees should be used. Unfortunately, the soil of the river-valley in which the nursery is located is too much like that of the hills. While throughout the valley there is a good, loamy-sand soil of about twelve inches' depth, this is immediately underlain by a coarse sand of the most porous character. The loamy soil has evidently been formed by the accretion of humus from the herbaceous, shrubby, and arborescent vegetation which has covered it, and not by the deposition of fertile silt. This factor alone is sufficient to make almost impossible the proper root development of forest trees. While, also, the light soil does not impart to nursery stock that vigor and stored energy which might be obtained from a heavier soil, it is, mechanically speaking, an excellent soil for the handling of trees. The water table is about eight feet below the level of the ground in the nursery, and on this account the soil does not dry out rapidly, except where it supports an excessive amount of vegetation. Since it is not advisable to water a soil of this character heavily, it becomes necessary to grow the seedlings and transplants with a wide spacing.

Even in the nursery, which is well protected, the desiccating effect of the spring winds is seriously felt. Whole beds have at times been dried out by these winds, and the seedlings have lost their foliage, and have even died. This, and the factor of summer drought, in beds too closely sown, have induced the ravages of fungi, among which, in the cases of jack pine and Scotch pine, undoubtedly occurs the well-known "Schütte" of European nurseries. Damping-off of young seedlings has also caused immense losses of all species. It was at first thought that the various fungi involved, having existed in the soil of the plum-thickets which covered this area, would be to some extent eradicated

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by cultivation and aëration. Such, however, has not been the case. The losses from damping-off have increased from year to year.

All things considered, it seems best that the nursery for the production of stock for sandhill planting should be kept in the sandhills, where the climatic conditions are the same as those encountered in the planting sites. It is, therefore, extremely necessary that the problems of changing the physical quality of the nursery soil, increasing its fertility, and eradicating those fungi which have proved so disastrous, should be solved by experiment; but no experiments have as yet been systematically undertaken. The purpose of this paper is, however, to review the progress which has been made in the solution of the problems met in the work of field planting.

Review of Experimental Work

Points to be Considered.—The differences in aspect and gradient presented by the broken and uneven topography of the sandhills, the differences in exposure to wind, the presence of depressions in which the fertile soil of the hills is collected and which each year receive more or less moisture from the higher ground, with other factors, give rise to types which must be recognized by the forester, as they have been recognized by nature in the distribution of the herbaceous plants of the region. To suppose that because the soil is uniformly sandy, a single species or a single method of procedure is sufficient, would undoubtedly prove fatal to the forester's enterprise. In the present work, four principal types have been recognized, namely, ridge, bottom, north slope, and south slope. To this list might be added east slope and west slope; but these are of minor importance and are intermediate in all their characteristics.

The ridge type is most exposed to winds from all directions. Its soil is very coarse, is composed almost wholly of silicon, and has a low moisture capacity. Vegetation is very scanty, and consists of yucca (*Yucca glauca*, Nutt.) and

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such grasses as the "Bunch-grass" (*Andropogon scoparius,* Michx.) and the tall reed-grass (*Calamovilfa longifolia,* Hack.). While the soil moisture probably never exceeds 4 per cent., the lack of vegetation makes possible a very stable supply.

The bottom type is least exposed to wind. On account of the stagnation of the air, day temperatures may become very high in situations of this class, and night temperatures very low. On the other hand, the soil is not so directly insolated as that of south slopes, and does not become so highly heated. More or less surface moisture drains into the bottoms, and some underground flow is evident. On account of the better soil and moisture supply, the vegetation is sometimes very heavy. It consists of such grasses as grama grass (*Bouteloua hirsuta,* Laq.), a coarse "Indian" grass (*Sorghastrum avenaceum,* Nash.), and such small shrubs as *Rosa arkansana,* Porter. The presence of this heavy vegetation induces, during the drier season, extreme drought conditions, and the normal moisture content of 6 to 8 per cent. may be reduced to 3 per cent., of which very little, if any, is available for plant growth.

The south slope presents the most difficult situation. Although its vegetation is scanty, and similar to that on the ridges, great loss of moisture occurs during the summer as a result of direct insolation and the heating of the soil to a great depth. On the other hand, in the early spring, moisture conditions are favorable for plant growth, because of the late melting of snowdrifts, which, during northerly winds, are formed on these slopes, and may remain until all other snow has disappeared. This factor is so important that all of the native arborescent growth of the sandhills is congregated on the south and southeast slopes. Plum-thickets (*Prunus americana*), hackberry (*Celtis occidentalis*), and even groups of ash (*Fraxinus lanceolata*) are found in situations of this kind, making but poor growth, but nevertheless existing as the result of moisture conditions induced by snowdrifts.

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With any species, the north slope type is the most favorable for planting operations. One-year seedlings of yellow pine have been planted on the cool, moist situations with great success, but their rate of growth here is so slow as to warrant some doubt as to the desirability of the practice. The soil is usually finer than on ridges and south slopes, contains much humus, and is not subject to drying out as the result of insolation. The heavy vegetation growing on north slopes demands considerable moisture, but its most serious effect upon planted trees is caused by shading. In addition to the dense grasses, there are frequently found on the north slopes, at certain elevations, belts of sandhill willow (*Salix humilis,* Marsh). These are undoubtedly induced by the outcrop of a water-bearing stratum, consisting of very fine clay in mixture with sand. Under these willows, moisture is always plentiful, and any tolerant tree should grow well.

Aside from determining the characteristics of the various situations more specifically than by means of general observations of the natural conditions and the growth of trees upon them, the 1909 experiments sought to measure the factors which might affect tree growth on each slope, and to express these quantitatively. In addition to this, the best species for use on each type was to be determined, as well as the best method of planting under each condition, the possibility of ameliorating the unfavorable conditions by cultivation of the soil, by protecting the trees from wind and insolation, etc.

System of Experiments.—In order to determine the points mentioned above, fifty sample plots were laid out early in the spring of 1909. These were in two groups or blocks, and covered the entire range of type conditions found in the hills. Block A occupied a strip which covers south slope, bottom, north slope, and ridge types. The north slope type in this block was not, however, typical, and already contained a number of trees of earlier planting. Consequently, another situation was chosen which includes a gentle (not typical) south slope, bottom, and typical north slope.

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Each plot of these blocks was made forty by forty feet, and the trees were spaced four by four feet, so that with a few exceptions each planted plot contained, at the outset, one hundred living trees. The records of the condition of the trees in these plots, observed three time during the season of 1909, together with the measurements of physical factors made in each plot or typical situation, form the basis for the conclusions so far reached. While the areas involved, and the number of trees planted, are not sufficient for final conclusions, the results obtained in 1909 have determined certain points very clearly, and indicated the lines which future experiments should follow.

Test of the Qualities of Various Sites (Experiment P-1).—In order to determine the qualities of the various sites, as shown by the growth of trees and by measurements of physical factors, western yellow pine stock was planted on a variety of situations, the quality of stock, method of handling, and method of planting being uniform throughout. In all of the plots where this stock was planted, soil surveys were made three times during the growing season, including measurements of the moisture conditions at twelve, twenty-four, thirty-six, and seventy-two inches depth, in each plot. Soil temperatures were measured in the middle of the summer, and the rate of evaporation, under typical weather conditions, was also determined by means of evaporometers (modified Pische instruments). The following tables show these points in detail for the four typical situations:

TABLE I

AMOUNT OF MOISTURE IN SOIL (PER CENT. OF DRY WEIGHT)

Type	At 12 inches			At 24 inches			At 36 inches			At 72 inches		
	May	July	Sept	May	July	Sept	May	July	Sept	May	July	Sept
So. slope .	4.06	1.94	3.11	4.77	1.62	3.12	4.29	1.78	3.18	3.87	2.75	3.30
Bottom ..	5.06	2.94	4.72	4.82	2.11	4.18	5.43	3.30	4.21	6.54	7.44	8.56
No. slope.	5.11	3.02	4.70	5.26	3.33	5.07	5.87	5.14	6.65	5.88	7.31	7.41
Ridge	3.33	4.01	3.58	4.38	3.79	3.85	5.22	3.67	3.70	5.36	4.18	4.94

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TABLE II

TEMPERATURE OF SOIL (DEGREES CENTIGRADE)

Type	At surface July 16	At depth 12 inches	
		May 15	July 16
South slope.....	59.10	15.60	25.10
Bottom.....	39.50	12.70	22.30
North slope.....	32.30	10.60	22.80
Ridge.....	48.85	13.90	24.30

TABLE III

RATE OF EVAPORATION WITH SOUTH WIND
(Expressed as percentage of greatest rate)

Type	Evaporation per cent.	Wind, miles per hour
South slope	82.5	....
Bottom	61.4	8.55
North slope.....	53.6	4.70
Ridge	100.0	21.10

TABLE IV

COMPARATIVE WIND VELOCITIES FOR 24 HOURS OR MORE

Type	Wind northwest	Wind southerly
Bottom.....	2.77 miles per hour	4.44 miles per hour
North slope.....	3.78 " " "	6.58 " " "
Ridge	7.12 " " "	8.47 " " "

TABLE V

PROPORTION OF TREES THRIFTY

(Percentage of trees planted)

Type	June	July	Sept.
South slope	94.	83.	64.
Bottom	92.5	88.5	54.5
North slope	100.0	99.	99.
Ridge.....	100.	100.	100.

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The most noteworthy feature of these results is the close relation between the soil-moisture conditions of the several types at the time of the July examination and the amount of fatality noted in September. The south slope, moist in the spring but severely insolated after the melting of the snow, shows in July great depreciation of moisture values and already considerable loss of planted stock. Almost every tree dead at that time had been partially covered by sand and was actually "baked." The drought, however, is not more severe than in the bottom type, where the total amount of moisture is somewhat greater, but the amount available to plants probably no greater. The great loss of trees in the bottom is undoubtedly due to the continued drought induced by the competition of native vegetation, which is not relieved until the fall rains begin. On the other hand, it is to be noted that at a depth of six feet, and less notably at a depth of three feet, the moisture increases steadily through the summer, probably from the drainage of the higher ground on either side. This moisture, however, does not rise sufficiently high to be of use to the trees, or to relieve the drought in the surface soil.

The north slope is much less severely insolated, is only moderately exposed to wind, and on this account is much more favorable for trees than the south slope or bottom. There is considerable depreciation of soil moisture, though not enough at any time to bring it so low as the normal moisture percentage for the other situations.

The success of the plantation on the ridge type furnishes the greatest surprise. Fully exposed to insolation, and whipped about by every gust of wind from any direction, the yellow pine in this situation came through the first season without loss. The results of another experiment, in which a windbreak was used, show that it is *not the factor of wind which has caused loss* in earlier plantations, and the results of soil moisture measurements seem to indicate very clearly that the great success of the trees here *is due to the constant moisture supply,* which is made possible by the almost complete absence of competitive vegetation.

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The character of each type situation having been generally known for some time prior to this experiment, and the results of the experiment anticipated, coördinate experiments were conducted during the same season, to determine what measures could be taken to ameliorate the unfavorable conditions of each situation.

Treatment of Various Types.—(A) In the case of the south slope, it was thought that the greatest success in planting could be obtained by the use of (1) the tree species having the greatest root depth, which would make accessible moisture supplies unaffected by the heating and drying of the soil; (2) by the use of a species from a northern latitude or high altitude, whose growth would commence early in the season, thus utilizing the moisture supply before the summer's heat had dissipated it; and (3) by the use of a nurse or cover tree, such as aspen, which would protect the soil from insolation.

The first and second points were covered in Experiments E-1 and E-3. In Experiment E-1, jack pine, Scotch pine and western yellow pine were planted side by side, under the most severe south slope conditions, their treatment throughout being the same. The stock used was of transplants two years in seedbed and one year in transplant-bed. It has always been noted in the nursery that the jack pine commences growth at least two weeks earlier than the yellow pine, which is, of course, a tree of low altitudes and southern latitudes. The Scotch pine is also somewhat earlier, but not so vigorous in its early seasonal growth as jack pine. For south slope situations the yellow pine should have a great advantage, inasmuch as it has more extensive roots of the tap-root character than the other species. Well-matured stock of Austrian pine should also have a great advantage in this situation. This species, as also Norway pine, another northern tree, was tried out on a less exposed south slope (Experiment E-3). The test does not, to any fair extent, exhibit the possibilities of Austrian pine, since it was impossible to obtain fully matured stock of the

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species; the two-year seedlings obtained were thrifty, but lacked the deep tap-root and the mass of fibrous roots which are characteristic of transplanted stock. Under the circumstances, the vitality shown by Austrian pine was remarkable, and entitles the species to further and more extensive tests. The number of trees of each species actually growing, and the number dead, at the time of each examination, are given in the following table:

TABLE VI

SUCCESS OF VARIOUS SPECIES ON SOUTH SLOPES

	Percentage of trees planted								
	Growing			Dormant			Dead		
	June	July	Sept.	June	July	Sept.	June	July	Sept.
Jack Pine	99	99	85	0	0	0	1	1	15
Scotch Pine.....	78	83	34	18	5	0	1	7	57
West. Yellow Pine...	94	83	64	4	4	0	0	8	34
Norway Pine	98	88	22	0	1	0	1	7	75
Austrian Pine.....	10	47	25	87	38	4	0	8	67

The condition of the trees of the several species in September indicates with clearness the great advantage of the early vigorous growth of jack pine. Having established itself early in the season, this species suffered comparatively little from the later drought. Moreover, the trees are long-stemmed, and were not baked by the hot sand to the same extent as the yellow pine. The long roots of yellow pine were doubtless of some advantage, but its growth is too sluggish to make it suitable for this situation. It is worthy of note that the Austrian pine, while losing many individuals, showed great persistence, four trees enduring the summer drought, although unable to obtain enough moisture for growth. This feature is very encouraging, and while, perhaps, the tree will not make rapid growth in soils so poor as are found on south slopes, it will probably make a better showing, during the first year or two in the field, than any other species except jack pine.

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The possibility of using aspen as a nurse, for the protection of conifers planted on south slopes, remained an unsolved problem at the end of the season. All of the aspen cuttings planted were affected by a fungous or bacterial disease, which, until it is carefully investigated, will prevent the successful planting of the nurse tree. A study of the moisture conditions in an aspen grove in the vicinity showed that, while in the spring the soil under the aspens was much more moist than under sod on the same slope, by the middle of the summer this relation had been reversed. It may be, therefore, simply through the protection from excessive insolation, and not by increasing the supply of available moisture, that the aspen will be useful as a nurse.

(B) In the case of the bottom type the difficulty met by the trees is mainly that of competing with native vegetation for the moisture of the soil. The insolation is moderately strong, the air temperatures are high, and the wind exposure is moderate. Any operation which will suppress vegetation, without checking the growth of the trees, should prove to be of great advantage. In one bottom situation (Experiment P-5), the value of cultivation of the soil was tested; in a second (Experiment P-3), the effects of burning the old grass prior to planting, and of mowing it and spreading it as a mulch, were compared with the results obtained under normal conditions of active vegetative growth.

In the first of these experiments, one plot of the usual size was completely plowed about a week prior to planting with yellow pine transplant stock. The sod broke down readily and the ground was well settled for planting when the operation was performed. A second plot was furrowed, the furrows following the lines of the prospective rows of trees, four feet apart, about ten inches wide and five to six inches deep. The trees were planted in the bottoms of the furrows, a system which has been much practiced in sand-hill planting. They were, therefore, removed from the most immediate competition. The third plot, lying between the

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others, was not treated, no vegetation being destroyed except that necessary in digging pits for the trees.

The following table indicates the effects of the various soil treatments:

TABLE VII

SUCCESS OF YELLOW PINE UNDER CULTIVATION

Treatment of plot	Percentage of trees planted								
	Growing			Dormant			Dead		
	June	July	Sept.	June	July	Sept.	June	July	Sept.
No cultivation	95	92	57	4	0	0	1	7	39
Furrows plowed.....	89	96	80	11	0	0	0	4	18
Completely plowed...	96	98	92	2	0	0	2	2	7

The soil of the three plots concerned was not exactly the same, being richest and heaviest on the area which was furrowed, and poorest and coarsest in the plot which was completely plowed. Unfortunately, the soil moisture conditions were not determined in each plot at each examination. The incomplete sets of samples taken, however, indicate that the great loss of planted stock in the untreated plot was due to the depletion of the soil moisture in midsummer. At a depth of twenty-four inches, the average moisture percentage in this plot in July was 2.04, as against 4.01 in September, which may be considered normal. The depletion, then, amounted to 49 per cent. of the normal supply. In the area which was plowed and cultivated, the moisture percentages were in July, 3.18, and in September, 3.72. The depletion amounted to only 17 per cent. of the normal supply. The effect on yellow pine was so beneficial that, figuring the value of the nursery stock at only $1.00 per 1,000 trees, the entire cost of plowing the ground was paid by the saving of plant material.

The advantage of the mulching and burning process was not so apparent. The depletion in July, at a depth of twelve inches, amounted in the case of the untreated plot to 52

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per cent. of the normal moisture content noted in September. In the burned plot it amounted to 41 per cent. and in the plot in which the grass was laid down as mulch, to 35 per cent. These amounts are not in proportion to the losses suffered in the three plots, and the conclusion is that the loss of moisture was not the determining factor. On the other hand, the treatment given seemed to have affected very materially the activities of grasshoppers, which were abundant during the late summer in the vicinity of the plots. The activity of the grasshoppers was slight in the area where the grass had been used as mulch, and where it to some extent prevented the growth of new grass. It was much greater where the new and old grass were mixed in normal proportions and even greater where there was no old grass, but a thrifty growth of new grass. The following table indicates, in addition to the number of trees growing, dormant, and dead, the number of the last class which had been girdled by the grasshoppers, either before or after death had occurred from other causes. It is unfortunate that observations were not made during the progress of their activities to determine to what extent they attacked thrifty trees.

TABLE VIII

EFFECT OF COVER TREATMENT ON SUCCESS OF YELLOW PINE

Treatment of cover	Percentage of trees planted									
	Growing			Dormant			Dead			Girdled
	June	July	Sept.	June	July	Sept.	June	July	Sept.	Sept.
Normal.....	90	85	52	8	4	0	0	9	44	29
Burned.....	90	93	46	10	2	0	0	5	51	39
Mulched	85	87	65	13	4	1	0	6	31	9

(C) The difficulties of the north slope situation are not great. In all of the early plantations the success has been very encouraging. Yellow pine has done well, even one-year-old seedlings making a good showing. It is realized, however, that the cool, moist qualities of the north slope

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are not such as to induce the most vigorous growth of yellow pine. A species adapted to a northern climate, if equally vigorous in its native habitat, should prove to be a more valuable species on the north slopes of the sandhills, where the presence of frost in the ground retards growth for at least two weeks in the spring after it has begun on other situations. The only treatment of this type, therefore, was a test of species, yellow pine and Scotch pine being compared. The comparison of the rate of growth of the two species can not be made for several years, but the success of the two during the first season is indicative of the possibilities of Scotch pine, which heretofore has not been given a thorough trial. While the comparison of yellow pine at the top of the slope, where vegetation is scanty, and at the bottom, where it is more dense, indicates that some cultivation of the soil in the latter situation would be desirable, yet the moisture conditions of the typical north slope situation are so good that this can not be considered in most cases necessary or of great importance. The comparisons made herewith are between 2-1 transplant stock of the two species.

TABLE IX

SUCCESS OF VARIOUS PINES ON NORTH SLOPES

Situation and species	Percentage of trees planted								
	Growing			Dormant			Dead		
	June	July	Sept.	June	July	Sept.	June	July	Sept.
Foot of slope; *Scotch*	51	89	82	40	5	0	0	4	15
Foot of slope; *Yellow* ...	100	99	82	0	0	0	0	1	17
Top of slope; *Yellow*....	95	99	99	5	0	0	0	1	1

(D) The ridge type, supposedly, is unfavorable to tree growth, principally on account of its exposure to all winds, and because of the poor quality of its coarse soil, which by chemical analysis is shown to contain over 97 per cent. of insoluble matter, as against 92 per cent. in the best, most fertile soils of the sandhills. It is especially lacking in

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potash and lime. It is so loose and coarse that any form of cultivation subjects it to wind erosion, which sometimes excavates "blow-outs" to a great depth. The scanty vegetation of these hill-tops must be considered beneficial. through the protection which it affords. The effect of competition in reducing the moisture content of the soil has already been shown to be of slight importance on this type.

An experiment was conducted to determine the importance of wind exposure during the period following the planting of yellow pine on the ridge type, when, it may be supposed, the danger of loss of moisture by transpiration is greatest. One plot of the usual size was enclosed by a fence made of two-inch slats four feet high. The spaces between the slats were about equal to the width of the slats. A second plot, similarly exposed, had no protection from wind. At the center of the enclosed plot, and at a distance of eighteen inches above the ground, the reduction of wind velocity amounted to about 24 per cent. of the wind outside, and the reduction of evaporation, as shown by the Pische instruments, amounted to 36 per cent. In spite of this effect of the windbreak in reducing the severity of the physical factors which might cause the death of the trees, 4 per cent. of those planted within the enclosure died between July and September, while no loss occurred in the plot which was fully exposed to the wind. The natural inference is that exposure to wind is not an important factor in causing the death of newly planted trees. The experiment has been carried further with the planting of the same number of trees in the fall, but the results of this test are not yet available.

In addition to these principal tests, which affect the possible treatment of the various types prior to planting, and the selection of the species to be used in each, other tests were made which refer more particularly to the growing of stock in the nursery, and the general principles of planting, applicable to any site or any species. These experiments were concerned (1) with the best method of planting;

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(2) the best age of stock to be used; (3) the advisability of grading, to raise the standard of vigor and prevent the planting of worthless stock; and (4) the best time for planting, as affected by the necessity of storing the trees in a storehouse or holding them in beds.

1. The loose character of the soil of the sandhills has made possible a very simple method of planting, practiced in early years, by which the trees can be set rapidly and cheaply. No excavation was made, but the roots were simply set in a slit made with the blade of a spade. The roots of the trees were thus placed in a narrow plane, having access to a very limited soil area. It was thought that this factor was responsible for much of the loss in early plantations, and a more careful process was inaugurated, which involved the excavation of a pit about seven inches square at the top, about twelve to fourteen inches deep, and usually not more than two by seven inches at the bottom. All of the pits were made by one man, and the planting done by another, so that frequently the size of the pit did not conform to the length and number of the roots, and the larger trees had access to no more soil area than the smaller ones. This process, which has been known as the "square-hole method" of planting, was doubtless the cause of much loss also.

In the experiment conducted in 1909, the results obtained by these two methods were compared with the results of a much more careful method, by which the pits were all dug to the full depth needed by each tree, the roots being separated by a mound of earth, formed by the hands of the planter, in the center of each pit. This separation of the roots gives the tree as a whole access to a greater amount of soil and soil moisture, which is an important consideration, since in the sandy soil the capillary movement of the soil moisture is very slow, and the roots may quickly exhaust a small area. The great advantage of this process over the other two planting methods is exhibited by the success of the three plantations during the first season. At the end of the season the following results were recorded:

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TABLE X

SUCCESS OF VARIOUS METHODS OF PLANTING

Method of planting	Percentage of trees planted		
	Thrifty	Failing	Dead
Mound method.....	70	4	26
Square-hole method	36	5	59
Slit method	42	4	54

The saving of stock by the most careful method of planting is so great as to more than offset the additional cost of the work of planting. The low percentage of survival throughout these plantations is due to the vigorous competition of native vegetation on the entire area, which was within the bottom type. The slight disadvantage of the square-hole method, as compared with the slit method of planting, is worthy of note, since it reverses the conclusions which have been drawn from more general observations.

2. It has, of course, always been generally understood that the most mature stock withstands the shock of transplanting best and adapts itself to new conditions most readily. The following figures, representing the survival of stock of various ages at the end of the first season in the field, are very enlightening and need no further explanation. The treatment at the time of planting was practically the same for all classes of stock.

In the case of yellow pine, the advantage of the 3-1 over the 2-1 stock is very slight, and indicates that the optimum age of stock is about three years, considering the expenses of the additional year in the nursery. The loss of seedling stock of Scotch pine is very striking, and indicates the mistake of using unhardened stock for the rigorous conditions of the sandhills.

3. The desirability of grading stock depends entirely on its uniformity, the cost of planting, and the experience of the planters. If the laborers working in the field can be

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TABLE XI

SUCCESS OF STOCK OF VARIOUS AGES

Class and age	Percentage of trees planted		
	Thrifty	Failing	Dead
Yellow Pine.			
Transplants, 3-1	88	0	12
" 2-1	82	1	17
" 1-1	50	1	49
Scotch Pine.			
Transplants, 2-1	82	3	15
" 1-1	63	10½	26½
Seedlings, 2-year	7	2	91

depended upon to discard trees which show a lack of vigor, or have been damaged in handling, there is no need of grading when the stock leaves the nursery. It may be stated as a general principle that with the high cost of labor in America, it is never desirable to return to the nursery, for additional growth, individual trees which have fallen behind the average rate of growth during the allotted time in the nursery.

The following figures apply only to yellow pine of the age of three years, once transplanted, but probably indicate with fairness the rules which should be followed in handling any stock at the Halsey Nursery. They represent the success during the first year in the field of three grades of stock of the same age and treatment, the grading having been made on the basis of actual size of plant, proportion between roots and stem, number and length of roots, and condition of buds.

The loss in the poorest class of stock, which represented about one-third of the stock taken from the nursery, does not seem to be sufficient to warrant its waste. There were a considerable number of trees of this grade which failed within a short time after their planting. Such trees as these, if they can be properly selected, should be discarded by the planters, since time is wasted in putting them into

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TABLE XII

SUCCESS OF THREE GRADES OF YELLOW PINE STOCK
(2-1 Transplants)

Grade	Percentage of trees planted											
	Thrifty			Dormant			Failing			Dead		
	June	July	Sept.	June	July	Sept.	June	July	Sept.	June	July	Sept.
Select	99	96	86	1	1	0	0	0	0	0	3	14
Medium ...	99	92	73	1	4	0	0	1	1	0	3	26
Cull	88	83	65	8	6	0	1	2	0	3	9	35

the ground. Beyond this, no selection or discrimination in treatment seems to be justified.

4. The spring planting period in the sandhills usually covers at least a month. Frequently, the growth of trees in the nursery begins two or three weeks before they can be planted in the field. To prevent this growth it is customary to dig the trees early in the season, and to store them in a cool room until they are needed. The advisability of this process is doubtful. If the trees can be taken directly from the nursery beds to the field, the danger of damage to the roots by abrasion, loss of soil-particles, and heating and drying, is greatly reduced. It is believed that this danger is almost as great as that arising from the handling of the trees after growth has started. The experiment conducted in 1909 bears out this assumption. One lot of trees was planted, early in the season, directly from the nursery; a second lot was dug at the same time and stored for twenty-five days; a third lot was taken from the nursery at the end of twenty-five days, and after growth of the terminal buds, amounting to nearly an inch, had taken place. The last two lots were planted at the same time. At the end of the season the following results were recorded:

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TABLE XIII

EFFECT OF STORING AND LATE PLANTING ON SUCCESS OF YELLOW PINE PLANTATIONS

Treatment of trees	Percentage of trees planted		
	Thrifty	Failing	Dead
Dug and planted early.....	89	1	10*
Dug early, stored 25 days....	90	3	7
Dug and planted late	82	0	18

* Killed by gophers.

The death of 10 per cent. of the trees planted at the early date has, of course, no bearing on the experiment, since this death was caused by the accidental interference of pocket-gophers, whose burrows were not present in the areas where the later plantations were made.

In brief, the results obtained during the first season of the experiments carried on in the Nebraska sandhills, indicate with clearness that the afforestation of the region with coniferous trees, and following the most scientific knowledge available, is not only possible, but much more easily accomplished than past experience had indicated. The most careful method of planting will yield the best results, and by the ultimate saving of material, will prove most profitable in the final cost of forming plantations. Stock for planting in the sandhills should be fully mature. Three years seems to be the best age for all species which have been handled as yet, although in the case of Austrian pine two years may be sufficient. All stock should have been once transplanted before final planting. Systematic grading of stock is unnecessary and unprofitable. The earliest planting will be the most successful, and in case trees must be planted late they will suffer no more in the nursery than in the storehouse, where there is the smallest chance of damage from heating.

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MANAGEMENT OF LOBLOLLY AND SHORTLEAF PINES*

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The loblolly and shortleaf pines are destined to be the conifers of the future in the southeastern States, yet at present shortleaf pine is one of the least known of the important American trees. These trees are abundant and regular seeders and make very rapid growth when young; together they will undoubtedly largely replace the slower growing and more refractory longleaf on all except the driest and most sandy soils. Loblolly and shortleaf can thus be regarded as complementary species over the southern Piedmont and coastal plain from northern New Jersey southwestward to the 97th meridian in Texas and Oklahoma; loblolly being adapted to moist or sandy soils, shortleaf supplanting it on dry soils that are not too light.

The important silvical considerations in developing a plan of management for these species are methods of securing reproduction, the rotation or size for obtaining maximum yield, and means for protection. A system must be sufficiently elastic to be adaptable to different forest types, or there must be different systems for different types; it must fill the industrial requirements of the region, that is, must permit cheap and efficient logging, and secure the production of merchantable grades of timber; and must not be excessive in the cost of securing protection. This is particularly necessary in the Southeast, where the States have either no system of forest fire protection, or have rigid laws but inefficient means of enforcing them.

* Management is here used in its fullest significance, implying the silvicultural régime, as well as the method of conducting the ultimate cuttings.

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Comparative Aggressiveness.—At the present time natural reproduction must be relied upon for restocking all land. Since loblolly and shortleaf compete not only with each other, but with several other pines as well, it is essential, in order to secure the reproduction of the desired species, to understand the local value of the different factors which determine their aggressiveness.

Loblolly occurs over an area of not less than 200,000 square miles, while its second growth in pure stands has stocked between ten and twelve million acres, in part old field and in part cut-over loblolly and longleaf pine lands. Shortleaf occupies an area exceeding 150,000 square miles, chiefly in the Piedmont region, where, associated with hardwoods, it is the dominant conifer. Although its second growth monopolizes some 4,000,000 acres of old field land east of the Mississippi River, it lacks, except well within the region of its optimum development, the aggressiveness of either the scrub or loblolly pines, and has surrendered to them, either wholly or in part, large areas over which it was formerly the exclusive or dominant conifer. Its inability to maintain its original position is due, of course, to no change in physiological characteristics; but the open old fields, the broken forest cover, and the more frequent fires have altered the relative value of those silvical factors which maintained the original forest equilibrium.

In the virgin forest, tolerance, ultimate height, longevity, and soil adaptability, especially with the seedling, controlled the position of the pines; while early and abundant seeding, easily wafted seed, and rapid initial height-growth are the qualities which facilitate the temporary appropriation of cleared land and open places in the forest. This altered value of reproductive factors is detrimental to shortleaf pine. Whenever shortleaf enters into competition with either loblolly or scrub pine for the possession of open land, the equilibrium between them is readjusted unfavorably to the shortleaf in the second growth.

The impingement of the loblolly has extended the line

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of tension between them in the competition of the second growth far to the westward of its original distribution on the lighter soils in southeastern Virginia and northeastern North Carolina, and to the northward in portions of South Carolina, Georgia, Alabama, and Mississippi. In competition with the scrub pine in Pennsylvania, Virginia, North Carolina, Kentucky, Tennessee, and southern Indiana, the scrub has encroached upon shortleaf pine, invading soils originally occupied by it and greatly reducing its abundance in the second growth. The transition zone between the shortleaf and longleaf pines is for the most part narrow and sharply defined, yet when they occur mixed, as on a narrow belt from northeastern Alabama to northeastern Texas, and in Moore and Montgomery counties, North Carolina, the equilibrium between them is readjusted in the second growth, favorably to the shortleaf when the longleaf is suppressed by hogs, and to the longleaf when fires are frequent. Even white pine, when associated with shortleaf, as in parts of Alleghany County, Maryland, and in the basin of the French Broad River, frequently exhibits greater resilience in its capacity to occupy open lands and better maintains its relative position in the second growth.

In spite of the feebler colonizing capacity which shortleaf pine exhibits when in immediate contact with loblolly and scrub pines, it bears seed both abundantly and regularly, and is practically the only commercial conifer over more than 100,000 square miles between north central Virginia, western Arkansas, and northeastern Texas, with a far wider potential range open for planting.

The tolerance of the second growth trees has an important bearing on the method of cutting. Since tolerance is partly an inherent character of a species and partly an expression of available soil moisture, loblolly, with its wide range of soil adaptability, exhibits greater fluctuations in its demands upon light than shortleaf. As the amount of available soil moisture decreases and approaches the minimum limit, the larger and more thrifty trees, with their

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deeper and more extensive root systems, reduce the moisture supply below the limit required by the subordinate classes, resulting in their death and a stand with isolated crowns. Loblolly pine is among the least tolerant of the species with which it is associated. Its seedlings will frequently come up beneath the mother trees, but remain for only a few years before they die. Its tolerance, however, rapidly decreases with age, especially on dry soils. In the old-field stands on dry soils each crown is well isolated by the fortieth or fiftieth year.

Shortleaf is less tolerant in early youth, seldom forming mats of seedlings beneath the mother trees, but it retains its tolerance to a much later age. A forty-year-old stand of shortleaf on the red clay (Cecil clay) hills will have from 50 to 60 per cent. more trees in it than a stand of loblolly the same age. (See table on page 97.)

Both loblolly and shortleaf tend to form even-aged stands whenever they occur pure. Even in mixture with hardwoods they frequently form even-aged groups. It is only where they form a very small percentage of the stand that they occur in irregular age-classes.

Neither loblolly nor shortleaf forms any known geographical varieties. Loblolly pines, however, is noteworthy on account of the many forest types it enters and the numerous species with which it is associated. The most important permanent types in which it occurs are:

1. Loblolly in permanent pure stands.
2. Loblolly with cypress and tupelo in swamps subject to periodic inundation.
3. Loblolly with white cedar and bays on wet soils.
4. Loblolly with pond pine and bays on sour, peaty soils.
5. Loblolly with yellow poplar, beech, and oaks on moist soils with stable moisture content.
6. Loblolly with gums and maple on periodically flooded soils.
7. Loblolly with longleaf pine on flatwoods.
8. Loblolly with broadleaf evergreens in maritime forest.

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9. Loblolly with shortleaf pine and oaks in the Mississippi Valley.

The most important temporary types in which it occurs are:

1. Pure or mixed stands in old fields on a wide range of soils.

2. Stands in which loblolly pine has replaced oaks and shortleaf pine on uplands of the Atlantic and Gulf coasts.

3. Where loblolly pine has replaced longleaf pine in flatwood soils and less frequently on better drained sandy soils and on savannas.

Shortleaf, on the other hand, is a component of fewer types and is found on a narrow range of sites. The permanent types of which it forms a part are:

1. Shortleaf with oaks and hickory.

2. Shortleaf with loblolly pine, oaks, and hickory in the Mississippi Valley.

3. Shortleaf overtopping scrub oaks.

4. Shortleaf pure.

The only important temporary type is pure or mixed stands in old fields on a comparatively narrow range of soils.

The rate of growth and yield of loblolly varies widely on different types; that of shortleaf varies less. Many of these types, on account of the limited area they occupy, are at present comparatively unimportant as sources of commercial timber, and their management will not be considered. Some of them, however, occupy permanent forest soils, and consequently will have relatively greater value in the future than they have at present. The management of both species will be considered only in the most important types of mixed forests and in pure stands.

Management of Mixed Stands.—Many of the same principles of management are applicable to mixed stands in which loblolly or shortleaf pine enters. In the mixed forests containing either species, culling is the prevailing practice of cutting, and the pine is removed alone or with one or

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more of the more valuable species. On each site a minimum diameter limit, based on the percentage of their annual increase in value at the local net stumpage prices, can be fixed for cutting the pine. In eastern North Carolina, with 6 per cent. gross as a profitable minimum interest rate, this diameter limit varies from thirteen to eighteen inches for loblolly. The small trees left below the diameter limit can be relied upon for seed trees. When mixed stands which contain loblolly or shortleaf are cut clean, seed trees should be left of pine and of other valuable species by cutting these species to a diameter limit and clean-cutting other species. As a rule, the reproduction of loblolly takes place freely in the mixed stands whenever sufficient light is given. On moist soils it is not necessary to burn the ground cover to secure reproduction, but sometimes by so doing a large amount of hardwood shoots will be destroyed, and this may be advantageous when it is desired to increase the proportion of pine. On the drier soils, where loblolly and shortleaf occur together, and are associated with hardwoods, burning is desirable if it is designed to encourage loblolly at the expense of shortleaf. Not burning encourages shortleaf, which reproduces better than loblolly on dry leaf litter. In the mixed forest of shortleaf pine and hardwoods it is seldom desirable to burn, except for the purpose of suppressing well-grown hardwood sprouts and in this way to furnish the pine with better light conditions for reproduction. As a rule, shortleaf pine lands which have been cut clean and on which seed trees of that species have been left are densely stocked with young shortleaf pines in a few years. Numerous examples of this have recently been seen in Virginia, North Carolina, Alabama, and Louisiana. Nearby seed-bearing trees of scrub pine should invariably be cut or winter girdled in advance of cutting shortleaf in order to exclude scrub pine from the young stand or reduce the amount of it in the young stand. If there is only a small proportion of scrub pine it will eventually be overtopped and suppressed; but where it produces seeds several years before

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the shortleaf, as it frequently does on account of its more regular seeding, it suppresses the young shortleaf during its rapid growth.

There is thus comparatively little difference in the system of management of mixed stands which contain either the loblolly or shortleaf pine. Mixed stands which contain shortleaf, on account of their drier sites, are more exposed to fire than mixed stands which contain loblolly.

Management of Pure Stands of Loblolly.—The management of pure stands is less difficult than that of mixed stands.

a. On the so-called "natural" or permanent loblolly soils this species is indigenous and forms pure even-aged stands. On such sites its greater tolerance and the greater recuperative power of the subordinate age-classes permits cutting to a diameter limit. In actual lumbering this practically amounts to removing a mature stand in two successive cuttings. The first cutting removes the larger trees to a diameter of from twelve to sixteen inches, according to the quality of site; the second cutting, made from fifteen to twenty-five years later, completes the removal. If the stand is more than forty-five years old when cut, there will be very little subsequent height-growth of the intermediate trees and no height growth of the suppressed trees that are left after lumbering; and consequently, no lengthening of their stems. Diameter accretion, however, will take place, rapidly in the intermediate and slowly in the suppressed trees, but sufficiently fast to justify a second cutting within from fifteen to twenty-five years. By this time the young pine growth, which will have appeared beneath the old trees, should be from thirty to fifty feet in height, the two age-classes resembling a two-storied stand. It is often possible, when the diameter limit is maintained at twelve to sixteen inches, to remove in the second cutting some of the advance growth of the young stand at the same time that the residue of the old stand is cut. In practice, this second cutting amounts to a heavy

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though irregular thinning of the young stands. This was practically the method used for cutting loblolly in eastern Virginia and North Carolina until after 1890, when it was superseded by clear cutting where the conditions justified it, or by reducing the diameter limit to ten inches. It is the system which seems best suited to pure loblolly on good sites. This method of cutting is an ideal system of logging loblolly pine, but is limited in its application to forests on the best class of soils.

While there are several objections to this method of cutting there are many reasons for its favor. These are:

1. The average annual increment is lower than with clean cutting. This is fully compensated for by the larger size of the logs.

2. Logging the old trees in young stands is somewhat more costly than clean cutting. It makes a thinning of the young stand possible, however, in extensive operations.

3. Some of the young trees are broken down by the larger trees, but with careful felling the number is small, since neither the older suppressed nor intermediate trees will have developed widespreading, heavy-limbed crowns and their heights will be low.

The presence of too many trees in the old stand tends to retard the height growth of nearby groups in the young stand, so the first cutting must be heavy.

It is neither necessary nor desirable to burn slash to secure reproduction on natural loblolly pine soils, but it is desirable to pile and burn tops during summer logging, especially if there is much young growth of pole size, since by so doing the danger of insect depredation is reduced. The system of cutting is one which has been satisfactory to the lumbermen for many years and its use has contributed not a little to maintaining the supply of loblolly pine in the Norfolk section. It is also commendable in affording heavy cuttings at intervals of not more than twenty-five years, and this should lead to its retention in place of clear cutting, except when it is possible to make thinnings in the subordinate classes.

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b. On dry soils, loblolly pine forms pure stands only in temporary forest types, that is, on old fields or where it has followed longleaf pine or shortleaf pine on forest soils and where these species have been cut clear and the soil made suitable for loblolly by burning. On the dryest soils, that is, on the sandhills or on the red clay uplands, the early acquired intolerance of loblolly pine produces a mature stand which at forty to fifty years contains comparatively few subordinate trees, their proportion usually being less than 30 per cent. of the entire stand.

The following table shows the distribution of classes in an old-field stand of loblolly pine on dry sandy soil formerly occupied by longleaf pine. The density is normal for the site and age of the stand.

NUMBER OF TREES OF LOBLOLLY PINE TO ONE ACRE ON DRY SANDY SOIL, STAND 70 YEARS OLD; UNTHINNED

Diameter Breast-high	Dominant	Intermediate	Suppressed
7	..	..	4
8	..	..	4
9	..	2	4
10	2	6	2
11	4	4	..
12	8	8	..
13	16	2	..
14	16	4	..
15	22	..	..
16	6	..	..
17	4	..	..
	78	26	14

The elimination of the subordinate trees takes place fully as rapidly on the dry and heavy clay soils of the Piedmont as on a sandy soil such as is shown in the example given above. After logging such stands, the smaller intermediate and the suppressed trees—the class of trees which would be left after logging—recuperate slowly. Since the suppressed trees are invariably short-bodied, a remunerative second

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cutting is greatly deferred. Clean cutting is desirable on all such sites. It the trees are wind-firm, isolated seed trees may be left; these should be well-selected dominant trees. If, as is frequently the case, on dry, heavy clays of the Piedmont, or when sand in the costal plain is underlain by hardpan, the trees are not wind-firm, seed trees may be left in groups. While suppressed trees will frequently seed soon after they are released, they can not be exclusively relied upon to produce enough fertile seed for a restocking, although they may materially contribute toward its completeness. On all such dry soils, that is, sand hills or Piedmont uplands, it is desirable to prepare a seedbed for loblolly by burning the ground cover, since loblolly reproduces best on dry soils when in immediate contact with the earth. On small tracts on farms, in place of burning, a seedbed may be prepared by raising up the leaf litter and using it for farm purposes. This is frequently done, though with no intention of securing reproduction, and good reproduction follows. On sites where a suitable mineral seedbed has been exposed, reproduction of loblolly already begins to take place by the time the stands are forty years old, although the seedlings die after a few years under the still too dense shade of the old trees. On the other hand, reproduction of loblolly pine takes place slowly on these dry sites where the leaf litter is deep and has not been disturbed. This was well shown by stands at Grimesland, Pitt County, North Carolina, examined in the spring of 1909. Loblolly has partially replaced longleaf pine on sandy-loam upland. The tract, which was near a dwelling, had been protected from fire, and hogs had been excluded from it for more than twenty years. The leaf litter had accumulated to a depth of from six to eight inches. Although there were large open areas, one to two rods square, and the surrounding loblolly pines bore seed abundantly, the species had been unable to complete the stocking on account of the dryness of the thick leaf litter. On the other hand, nearby open lands, which had been occasionally burned and

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which were used as a range for hogs, were well stocked. While burning is desirable to facilitate obtaining reproduction on the Piedmont upland and on dry, sandy soil, it is neither necessary nor desirable on these sites as a protective measure for old timber. The ground cover rarely becomes sufficiently dense for an accidental spring fire to endanger the stand. Silviculturally, it is also undesirable to destroy the humus on the clay soils. The water table is low, and the amount of available soil moisture, on account of the large amount which is hygroscopically held in the fine-grained clay soils, is small during the autumn; consequently the humus covering should never be destroyed except when it is necessary to do so to obtain reproduction.

c. Where loblolly has followed longleaf pine on flatwood soils, some modification of the system proposed for the driest sites, that is, for the sandhills and for red clay Piedmont uplands, can be used. The flatwoods merge on the one side, as their soil becomes drier, into the sandhills, or in Texas, with lessened rainfall, into dry prairie, or into post oak forest. As the drainage becomes poorer, they pass on the Atlantic coast into savannas and pond pine "pocosons," and on the Gulf coast into wet prairie. On flatwood soils the rate of growth of loblolly pine is usually slower than on the "natural" soils, but is well sustained; its tolerance is good, and slender codominant trees from forty to sixty years old recuperate fairly rapidly. On the moister phases on these types, for this reason, culling to a diameter limit can be practiced; but as the soils become drier, this method of cutting ceases to be advisable and clean cutting should be used. To obtain reproduction of loblolly pine on the flatwoods, it is necessary as a rule to prepare a seedbed by burning, although when logging is done during wet weather, either by teams or with a steam skidder, there will usually be enough mineral soil exposed to obtain excellent results. The flatwoods forest is one of the most extensive types in which loblolly grows. At the present time, on account of the prevalence of fires, young growth occurs

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only in small and irregular patches, and hardwoods, especially scrub oaks, are replacing the pine, since they can frequently become established before a fire and can reëstablish themselves by shoots even if killed back. When their cover is sufficiently dense they exclude the pines completely. It is absolutely essential to protect young growth from fire on this type for from eight to twelve years, since the soil becomes covered with a dense grass soon after lumbering and its burning seriously interferes with the establishment of a young growth. As a rule, stands of poles and old timber which become foul as the density declines require burning to protect them.

Management of Pure Stands of Shortleaf Pine.—Shortleaf pine when in pure stands, either old-field stands or on forest soils, is adapted to clean cutting, seed trees being left as recommended for the trees in mixed stands. While slash can be burned, as a protective measure, it is not necessary to burn to secure reproduction, as it is in the case of loblolly on dry soils. On account of the natural deficiency of the clays in soil moisture, and the desirability of preserving the humus to protect the soil, it is also advisable to burn the ground cover as a method of protecting pole and mature timber.

Culmination of Volume Growth.—On large tracts on which loblolly is being cut, there will invariably be found several different forest types, each of which will require a different method of management in order to secure the best results. The conditions are further complicated by the different periods at which volume increment culminates on the different types. With loblolly, the earlier the loss of tolerance the earlier the culmination of volume increment. For this reason, on the natural loblolly soils, where the tree endures considerable crowding until late in life, the rate of volume increment is well maintained, and the cutting of a stand may be deferred many years past maturity without a serious increase in the production cost through the interest on the investment's accumulating much faster than

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the increment. On dry soils, when culmination may be followed by an actual decline in the total volume of the stand, there may be, if cutting is deferred, a great increase in the production cost. This is more marked in the production of cordwood than in sawtimber, which is sustained by the increase in volume increment.

The following table shows the yield in board feet and cords and the corresponding cost of production in typical old-field stands on upland clays of good quality. After the fiftieth year, when the rate of annual growth begins to decline, there is a sharp rise in the cost of production.

Age of stand—years	Yield per acre—board feet	Cost per 1,000 feet	Yield per acre cords, trees 5 in. and over	Cost per cord
30	....	....	12	$0.45
40	6,400	$4.70	37	.31
50	10,900	4.90	58	.38
60	12,580	7.01	61	.65

On soils of better quality, on which the annual volume production is better maintained, the cost of production may be somewhat more in younger stands, but there is no such rapid increase in production cost by holding after maturity, since the volume of the stand continues to increase slowly to a great age.

Shortleaf pine in old-field stands exhibits the same characteristics, but in a less striking manner, since its greater tolerance later in life leads to slower thinning and a later culmination of the yield, especially of the yield in board feet. The more rapid decrease in the number of trees to the acre and the corresponding decline in basal areas of stands of loblolly pine of the same age on the Piedmont uplands, explain why its yield on the upland clays culminates so much more abruptly.

Unthinned stands of loblolly attain a maximum yield long before those of shortleaf. The volume of the stands then actually declines as the tolerance of the tree is lost, and

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	Shortleaf Pine			Loblolly Pine		
Age of stand—years	No. of trees per acre	Basal area—square feet	Approximate yield—board feet	No. of trees per acre	Basal area—square feet	Approximate yield—board feet
25	1,300	214	.....	848	201	10,000
50	540	201	15,000	199	142	24,000
70	250	170	18,000	92	112	18,000

the number of trees to the acre, as well as the basal area, becomes smaller. The eventual yield of loblolly stands is no greater than that of the slower growing and more tolerant shortleaf, although the average diameter of loblolly is greater.

Thinnings.—Both loblolly and shortleaf pines respond to well-made thinnings by greatly accelerated growth. Any scheme of management for these species is incomplete without a method for thinning. They occupy in pure, even-aged stands a large area of farm forest in thickly settled communities, near either towns or factories, that is, in situations which assure a continuous market for cordwood. Such conditions not only render thinnings possible, but in many cases even profitable. Special thinnings, of course, are impossible on larger tracts used for the production of sawmill timber.

Since the power of recuperation of the intermediate and suppressed trees decreases with the age of the stands and with the length of the period of overcrowding, thinnings of shortleaf and loblolly on drier soils must be limited to the subordinate classes in the old stands. In young stands which are thinned when not more than twenty-five years old, many advance-growth dominant trees can be removed, since the intermediate trees of this age still retain recuperative power, and have approximately the same height as dominant trees, as well as straighter, clearer, and better formed stems. With loblolly the chief value of thinning, especially in the older stands on dry soils, is to save the trees which would be lost by dying. There would be comparatively little accelerated growth, for natural thinning

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takes place so rapidly that there is no prolonged crowding to retard the diameter increment of the dominant trees. On the other hand, on those sites where crowding does take place, that is, on stands on wet and moist soils, thinnings of the young stands will greatly accelerate the diameter growth of the dominant trees.

In the case of shortleaf, the effects of relieving the overcrowding which results from its prolonged tolerance are shown in greatly accelerated diameter increment and earlier maturity of the stand. The result of unsystematic thinning with shortleaf pine stands is shown by the following table, taken from a study of shortleaf pine in middle Virginia:

Age of stand, years	Number of trees to acre in unthinned stands	Number of trees to acre in thinned stands	Approximate number of trees to be removed in thinning a previously thinned stand	Yield of trees 9 inches and over in board feet	
				Unthinned stands	Thinned stands
20	1,950	....	980	....	....
25	1,440	970	205	....	....
30	1,235	765	150	....	8,400
35	1,030	615	110	....	13,400
40	860	505	85	6,000	16,400
45	710	420	65	10,200	18,600
50	335	355	55	13,100	20,200
55	480	300	45	15,300	21,800
60	395	255	....	....	....

Systematic thinnings limited to the subordinate groups should produce much better results than those shown in the table, and such thinnings must form an important part in the future management of shortleaf pine.

Legalizing Burning.—Burning to secure reproduction and as a protection for old timber on sites which rapidly become foul through the accumulation of dead shrubs, such as gallberry and fetter-bush, are measures which are antagonistic to the generally advocated policy for protecting pine lands in the southern States. There is no doubt that reproduction of pine has been prevented over an enormous area by annual or periodic burning. But it is equally true that on dry soils when the water level is low, one slow

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winter burning is desirable, in order to expose the mineral soil as a seedbed for loblolly. The sandy flatwood soils, with a water table seldom ten feet below the surface, are only slightly injured by fire. As pine stands on these soils begin to thin out, a dense undergrowth comes in, and as this undergrowth dies a large quantity of inflammable material accumulates. Unless this is removed by yearly winter burnings it places pole-sized and older timber in jeopardy during a dry, windy spring, when an accidental fire might kill a large amount of timber. This is so well recognized that yearly burning of the forest litter to protect valuable timber has been practiced for two centuries, and laws more than 100 years old in North Carolina, South Carolina, and probably in other southern States provide for burning by giving owners the right to burn their own forest lands. Land with mature timber of longleaf pine on it is yearly burned to protect it. Such burning is not considered necessary until the cover opens up, the density declines, and shortlived shrubs begin to form a heavy ground cover.

It is desirable that cognizance should be taken of the necessity for burning on such sites and the conditions under which it is really necessary in recommending forest fire legislation in the southern States. So long as no provision is made for burning under any conditions, general fire laws will inevitably be opposed by owners of mature timber on foul sites who are unwilling to take the risk which would follow the accumulation of dead shrubs for five or more years. The experience of these men counts for much, and their influence will frequently bar progressive forest fire legislation. On the flatwoods of the coastal plain burning should be legalized by the reënactment of the old burning laws, but their application should be limited to certain soil types or counties; and written authority should be required for burning from the county commissioners when there is no forest officer who can have control. There should be further provisions requiring fire lanes to be provided around any land which is burned in order to prevent the escape of

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fire to other land. Since there is no snow in the coastal plain on which slash can be burned, its burning is attended with greater danger than burning in the northern pineries and should never be undertaken unless the weather conditions are favorable and the brush has been well piled.

On account of their rapid growth, the ease with which they can be managed, and the cheapness and thoroughness of restocking by means of natural reproduction, these two pines must contribute very largely to the future timber supply of the eastern United States. Their hardiness and adaptability do not indicate that skill is not required in their management, but rather that on account of these qualities they will better respond to discriminating treatment. Neither in systems of cutting, nor in means of securing reproduction, nor in obtaining fire protection can general measures be recommended. A separate system must be designed and carried out for each forest type, and since the forest types seldom cover extensive areas, any large tract of forest land will probably contain several important and diverse types for which different systems of management must be employed if their highest productivity is to be secured.

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REGULATING THE ANNUAL CUT ON NATIONAL FORESTS

S. L. MOORE

Contributed

All foresters in the Government service have long felt the necessity for some systematic regulation of the annual timber cut upon the National Forests; the need of placing the Forests upon a basis of sustained annual or periodic yield; the urgency of establishing an annual cutting budget. In a joint article by Messrs. Zon and Clapp, in the agricultural "Year Book" for 1907, attention was first called to the fact that a beginning had been made, and that "the annual cut on all the Forests is being definitely limited as fast as the necessary data on which to base this action can be collected."

Rational regulation of the timber cut is, of course, one of the ultimate objects of a sound forest administration. Like many other desirable features of Government forest administration, this work cannot be taken up and at once carried through to completion because of lack of funds, and, in consequence, of competent men. Other exigencies, too, have delayed the work of establishing a definite limitation of the annual cut from the various National Forests. The problem of regulating the cut has, however, developed into definite form, and it is the aim of this article to point out briefly some of the practical difficulties met with, and to show what efforts are being made to bring about a satisfactory regulation.

Preliminary Stages

If the Forest Service, with a fair portion of its present force, had but one National Forest to administer, instead

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of one hundred and forty-two, the regulation of its annual or periodic cut might be placed upon a rational basis within six months. Suppose the one Forest were a small, isolated one, of only 500,000 acres. In a single season a moderately large field party could make a complete estimate of the standing timber and gather ample growth data upon which to base figures of annual yield for the entire Forest. Thenceforth, if the Government were in a position to dictate the amount of timber which the consumers of the region would be permitted to use, it would be comparatively easy to manage this Forest on a basis of sustained periodic yield.

In contrast to such a hypothetical case, the task of the Government foresters is complicated and magnified a hundredfold. The total area involved is tremendous in extent and the conditions are appalling in variety. The ideal plan, and what every forester would like, would be to proceed with the one hundred and sixty odd million acres as might be done with the 500,000-acre tract. But lack of money, men, and time from other duties to accomplish this is self-evident. To be sure, there are certain small areas in some of the National Forests, and a few entire Forests, for which working plans, more or less detailed, and based upon carefully collected data of growth and stands, have already been made. But the total acreage of such areas is pitifully small in contrast to the total acreage under administration.

In the face of lack of definite data upon which to base regulation, the forest administration has been guided by a policy of conservatism which has, with years, gradually grown more conservative, with the purpose of keeping the cut on the safe side, until money and opportunity may be available to place the work on a more satisfactory basis. Such studies of growth and yield as have been made, insufficient though they are, have yet served as a general guide to determine what cutting is conservative. On a given Forest it has been the aim to consider each cutting area (usually a particular timber sale) as a unit, and to mark

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the timber for cutting with a view to retaining a portion of the present stand for an early second cut, or to securing satisfactory natural reproduction within the shortest possible period. Such methods must serve temporarily, until it is possible to formulate specific plans for managing the growth of the Forest as a whole, with the object of producing a sustained periodic yield.

Difficulties Encountered

I shall enumerate briefly some of the greater difficulties in the way of the immediate formulation and execution of definite plans for the regulation of the cut. Of these, some might be overcome at once were the activities of the Forest Service not limited by lack of funds; others are due to conditions which could not be remedied so readily.

1. Lack of accurate timber estimates. The absolute need of accurate estimates as a basis for all management is too axiomatic to require discussion. Close estimates can be made only at great cost, and when there are so many demands upon the funds allotted for the administration of the Forests and upon the time of the officers employed, only a small amount of this work can be done each year.

2. Lack of growth and yield tables. These are, of course, as essential as the estimates of standing timber, and the same difficulty, lack of men and money, retards the work of collecting data for such tables.

3. Uncertainty of markets and demand. The utilization of the timber growing in the National Forests depends upon the existence of convenient markets with a demand for timber. Where markets exist, operators are easily found to log and manufacture the timber for consumers. Suppose that on a certain Forest an accurate estimate of the timber has been completed and a plan for the regulation of the cut formulated, based upon reliable growth and yield data. Suppose the forest supervisor has such a plan, very simple and explicit, at hand for his guidance. His difficulties have

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in reality just begun. In his efforts to get such timber as he desires cut, when and where he wants it cut, he is, as a rule, forced finally to compromise with the timber purchasers. In many cases his Forest, or large portions of it, may be totally inaccessible to any markets. He would soon find the well-drawn plan for the regulation of the annual cut impossible to execute. He is at a standstill, and can only wait until conditions change for the better, so far as forest management is concerned. But even where markets do exist, the fluctuation of the demand is frequently enormous from year to year, and this further complicates the carrying out of any plans for a periodic yield.

In many parts of the West the region comprising the natural market for National Forest timber is as yet undeveloped, or just bordering upon development. What the future population of a given region will become, and what demands will be made upon the Forest along with the growth of this population, are wholly matters of conjecture. Confronted by such a situation, the forester is deeply impressed with the need for conservatism in all his plans and feels as though he ought to "stand pat" absolutely, until he gets a better idea of the probable future development of this particular region.

4. Selfish interests. I have just described a condition existing in undeveloped and unsettled regions. In other localities settlement has become crowded and the immediate demands upon the timber resources of the neighboring National Forests are heavy. Here the difficulty is to limit the demand for timber. People are accustomed to have all the timber they desire if they pay for it. When the forester, who foresees an inevitable shortage, begins to shut down on the present supply, a strong adverse public sentiment is at once aroused. Since the National Forests are primarily the property of the people, their demand to use them as they see fit cannot be arbitrarily denied with impunity. The only hope lies in bringing the people to a realization of the necessity for present restriction, and

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meantime to effect the best possible compromise with the insistent demand.

5. Large supplies of dead timber. Many National Forests have an immense supply of fire-killed timber on vast burned areas, much of which is at present merchantable, but yearly depreciating in value. The plain necessity of securing the utilization of this supply as rapidly as possible demands the postponement of cuttings in stands of green timber, which in turn means delay in the initiation of plans for scientific management of the Forests.

6. Insect damage and other injuries. Notably on the Black Hills Forest, and to a smaller though nevertheless alarming extent on many other Forests, great damage is done by insect ravages. In such cases the forester must bend all his energies to combating the infestations. Only after the trouble is under control can he pause for time to devise and put into effect plans for a regulation of the cut.

Present State of Regulation

After this brief and incomplete statement of some of the difficulties encountered, I shall describe in a general way what is now being done toward regulating the annual cut.

The preliminary report made upon an area to be proclaimed a National Forest always gave an estimate of the timber resources of the area. This estimate was, of necessity, roughly made. As soon as a National Forest was placed under administration and local officers were permanently assigned, these officers began to accumulate valuable knowledge of the timber of the Forest. Beginning with the year 1907, every forest supervisor was required to prepare an estimate of the timber upon his Forest. These estimates were compiled in detail, by townships or, more commonly, by natural topographic logging units. Much of the field work had to be done by forest rangers who had little or no previous experience in timber estimating. But the resulting figures furnished a definite basis for future revisions.

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The annual revision of the timber estimate has become one of the regular duties of the forest supervisor. It is safe to assume that each revision brings a closer approximation to the actual stand of timber. By this method, within a very few years, wholly reliable estimates for the entire area of Natural Forests will be available. The estimates as at present compiled show, separately, green and dead timber, sawtimber and cordwood, for each of the commercial species.

While this work is being done for the entire area of National Forests, special estimates are being made for limited areas or single Forests which demand immediate attention. Under the designation of "reconnaissance work," crews of expert lumbermen, technical men, and especially competent rangers are assigned to the work of making accurate estimates of those areas which will require careful regulation of the cut within the immediate or near future by reason of the very limited timber supply or heavy demand. The amount of this work is, of course, limited by the funds available. Where completed, it is sufficiently accurate and definite to base upon it rough working plans.

A number of growth tables for the important western species have already been made by the Forest Service. But the number of growth studies for a given species still seems very meager indeed to the forester who is preparing a working plan for a given Forest. At present he often finds that the only existing figures for the species with which he is concerned are based upon the growth of that species at the extreme limit of its range from the locality in which he is interested. Such figures can be applied only approximately. It is, therefore, extremely urgent to increase the work of making growth studies, and to obtain as soon as possible for every locality tables of growth and yield which may be applied with a feeling of safety.

Leaving out of consideration the very limited areas which have been carefully estimated and covered by general working plans, the regulation of the annual cut upon each

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National Forest is at present based upon a very conservative estimate of the rate of growth and the total stand of the Forest. From the total estimated stand is calculated the annual yield. The actual annual cut is then compared with the calculated yield. In some cases the actual annual cut falls so far short of the estimated yield that it is unecessary for the present to prescribe any definite limitations of the annual cut. In other cases, the annual cut equals or closely approaches the estimated yield, and it is clearly necessary to limit the cut. On those Forests where a limitation of the annual cut is prescribed, the supervisor is instructed to restrict, so far as practicable, the amount of timber cut, in sales and under "free-use," to the limit established.

So far as possible, cuttings in virgin stands take the form of improvement cuttings. As would be expected, almost all the stands of virgin timber require an immediate improvement cutting to bring them into shape for systematic management. Since a prospective timber purchaser always desires to cut in the most accessible timber, it is far from easy for the supervisor to direct cuttings as he wishes. The plan of extending such preliminary improvement cuttings over the entire Forest can be effected in large measure by adjusting stumpage prices on a scale of accessibility. Only by making it the self-interest of the timber purchaser to cut in a certain locality can the supervisor control the location of cuttings.

It is plain from the foregoing that we are still far from the desired end of having working plans with a definite annual or periodic yield for all the Forests under Government administration. In an article printed in the *Proceedings of the Society of American Foresters,* for October, 1908, Professor H. S. Graves makes the statement that "The Indian Forest Service has been working now for a great many years and has working plans for only about 35 per cent. of the Government forests." Whether we shall equal, surpass, or fall short of this record remains to be seen.

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Future Possibilities

It is always pleasing to look into the future with the feeling that changed conditions will undoubtedly make the way easier for more intensive and successful forest management. In the particular of regulating the annual cut on the Forests, I believe several factors will come into play in the not too distant future which will materially assist the forester. Perhaps the most important will be the ultimate completion of a system of roads and trails which has already been started as permanent improvement work in the Forests. This, in connection with the increase of stumpage values, will eliminate the bar of "inaccessibility" which at present ties up so large a part of the National timber resources. Increased operations by small portable sawmills (as prophesied by E. A. Sherman in an article in the *Forestry Quarterly* for December, 1908) will also assist in the forester's plan for properly distributing his cuttings. The increase in demand for all sizes and species will be a help. Additional and more valuable data concerning growth and yield will speedily be acquired. And as the purposes and advantages of forest management become more clearly understood by the popular mind, the plans of the forester will meet with more hearty support and coöperation.

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THE GROWING OF EUCALYPTS

FRED G. PLUMMER

Presented before the Society January 19, 1910

The founder and leader of the Conservation movement, Mr. Gifford Pinchot, has for many years urged the proper use and protection of our present forests, the restocking of denuded areas, and the planting of new forests. A thousand times he has said that four-fifths of the standing timber in the United States is owned by private parties, and he has therefore carried on a campaign of education so persistent that all well-informed persons are now familiar with certain general facts: that only two-fifths of the United States was originally forested or wooded; that three-fourths of this has been culled or cut; that the present rate of destruction of trees is three times that of growth, and that a timber famine is in sight. As a result of his teachings every schoolboy and schoolgirl knows that we must make the best use of what is left and that we must now grow trees. That is my subject—we must grow trees.

No problem in conservation should be considered alone; the question of extensive tree planting in order to avert a wood famine should not be divorced from that of the utilization of soils and the protection of watersheds. Although in various parts of the United States slow-growing trees are raised for profit, and although the natural reproduction in forested areas is vigorous, I submit that these factors are covered by the statement that the destruction of trees exceeds their growth. The real problem, the great problem, must be solved another way. We must raise such trees as will overtake and pass the rate of consumption, and we must plant them where they will do the most good. Are there such trees? Is there such a place?

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There is a tree which, firm-rooted to withstand the winds, well crowned to collect the dews, grows faster than the cottonwood, taller than the redwood, straight as the fir. Its timber is as strong as oak, as elastic as hickory, as beautiful as maple, as enduring as cedar. It grows from seed or sprout, gives a second growth when cut, is hardy in youth and in age, and is ever-green and ever-living. In all its parts of stem, branch, leaf, and flower, it has nothing harmful to man. It will grow upon soil useless for other crops and will yield cordwood in four years, ties and poles in seven, lumber in twelve, and as an investment will pay compound interest. It will drain lands which are too wet and moisten lands which are too dry. Though not tolerant of shade, it will cover and improve a watershed without vampiring its own progeny. It can thrive upon summits, in sheltered valleys, upon dry plains or in the swamps, inland or on coasts, and live with six or with sixty inches of rain a year.

Its clean, self-pruned bole, if well seasoned, yields lumber which will neither warp nor check, resists decay or destruction by teredo. When freshly cut it is comparatively soft and easy to work and becomes harder and more enduring with age. Its timber products are valuable either for flooring or wainscoting, cooperage, vehicles, or furniture. It takes a polish equal to the best hardwoods and discloses a variety of grains.

Not only is this tree, itself, immune from disease, but, on the contrary, while oxygenating and perfuming the air, it exhales a healing influence for man. It blooms twice a year, and without attracting or harboring pests, furnishes honey for the bee and casts upon the ground a shower of fertile fruit. Such is the tree.

There are portions of our land, in the far Southwest; fertile but unproductive, glorious in sunlight, air, and scenery, yet desolate save under the magic of reclamation. They are short of water, and therefore of trees; or, if you prefer, they are short of trees, and therefore of water.

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This region was once the locus of a great civilization, perhaps older than that of India. It will some day support another people, higher and better. From San Diego and Monterey on the Pacific to El Paso and Santa Fé, it was the dreamy *mañana* country, the land of *poco tiempo*. Such is the place.

Will the tree grow in the place? Indeed it will, and also in other regions where the climate will not kill it, for it is sensitive to severe frost. It is the eucalyptus.

All of this, of course, is not news. The bibliography of eucalyptus is large. A memorandum of books and articles assembled in connection with this paper contains 221 items, and is far from complete. A useful publication is the "Handbook for Eucalyptus Planters," Circular No. 2 of the California State Board of Forestry, by G. B. Lull, prepared in coöperation with the Forest Service.

My purpose to-night is to arouse some enthusiasm on the subject of this extraordinary tree. This paper is not intended to be technical, because the treatment of the subject does not demand any refined analyses. No extensive tables are needed to show that eucalyptus grows faster than this or that genus, when it exceeds the best of them, two to one.

If eucalypts are to help solve the forest problem, they must be planted on a gigantic scale. There is no danger of over-production, because it is certain that such plantations will pay. This does not mean that everybody should go to planting eucalypts. Personal attention, combined with knowledge and practical training, are absolutely required for success in this as in any other enterprise.

In the portions of our land which other trees naturally cover, and where they reproduce themselves, the rate of growth is slow, although this may be sufficient to maintain a forest; but after extensive fires or destructive logging, it requires seventy-five to 125 years to replace an average stand. We can not materially hasten this growth, nor can we plant as rapidly as nature does. Unfortunately, in the

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mixed forests it frequently happens that the new growth after a burn consists of the less desirable species.

On the National Forests the seeds of our best trees are generally the heaviest and most relished by rodents, while the light seeds of poorer species are scattered by the winds. Thus the white fir has an advantage over the sugar pine and the hemlock over the Douglas fir.

But the vital point in the consideration of forest extension in the Northwest or in the East is the slow rate of growth. We can never induce a private owner to plant trees in the hope of a crop in seventy-five years, nor in fifty years, nor even in twenty-five years, particularly if State and county taxes on his forest tract bid fair to eat up all its profits, while he takes all the risk from fire and pests.

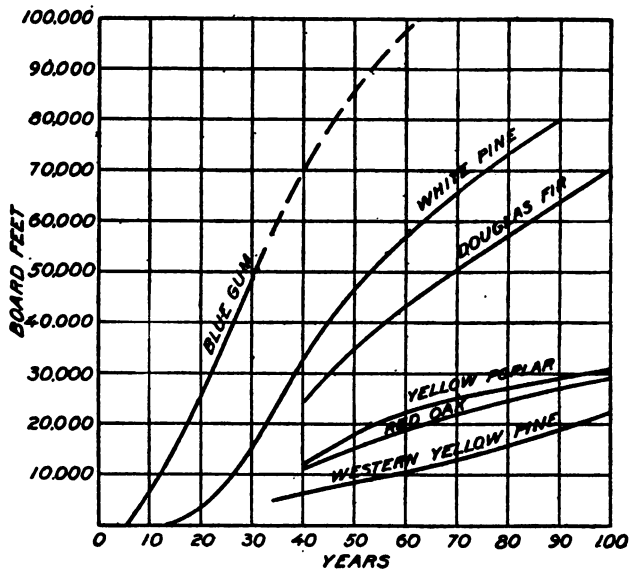

Diagram showing yield per acre, under best conditions, of Eucalyptus (Blue Gum) compared with other trees. From data in the Forest Service.

The accompanying diagram, showing the yield of eucalypts and other trees per acre under best conditions, proves

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that this forest wonder is in a class all by itself. Some authenticated cases of rapid growth read like fairy tales: 45 feet high in 2½ years; 125 feet in 9 years; 14 inches in diameter in 5 years; 9 feet in diameter in 25 years; three-year-old sprouts have cut 20 full cords to the acre. Stories come from Australia that eucalypts reach a height of 400 or more feet with a diameter of 15 feet and, exceptionally, 30 feet; single planks may be obtained 150 feet long. One tree was measured by a surveyor and found to be 471 feet high; another was 295 feet to the first branch. They live to be 500 years old, and their annual yield per acre is as high as 500 cubic feet.

During the past eight years the Forest Service has done a great deal of planting, considering that there has been no special appropriation for that purpose. Last year this work, exclusive of seed sowing, covered 1,700 acres and 622,000 trees. The figures sound large, but they are almost insignificant, except as evidencing good intentions. If plotted on an official map of the United States, the whole area planted would not be big enough to be noticed, unless attention was specially called to the area.

There are at least a million acres of Government land in the National Forests of the Southwest which will raise eucalypts. Most of this land now supports a chaparral cover and is included in the Forests for the purpose of protecting watersheds and because it may be restocked with trees. No one wants it; no one could make a living on it by agriculture. The Government should plant eucalypts on all of it and thus improve the watersheds and get the crop. It would pay.

Even though the facts relating to eucalypts have been published time and again, a quick summary of them is presented, since comparatively few persons outside of California have given the subject special attention.

Eucalypts are native to Australia and the neighboring islands. They were discovered in Tasmania by a French botanist, Labillardiere, in 1792, but it was not until 1854

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to 1856 that they were introduced into southern Europe, India, South America, and last of all into California, in 1865. Since then they have also been grown in South Africa, where they have been raised from seed and are therefore free from fungoid and insect pests. There are probably more eucalypt plantations in South Africa than in any other country, but the industry is rapidly gaining ground in the southwestern United States. It is probable that, if we wished, we could lead the world in the growing of this wonderful tree.

Australia is a semi-tropic country and of course the numerous attempts at raising eucalypts in cold regions have failed, but in California it has long since passed the experimental stage. The Santa Fé Railroad has put out about 5,000,000 trees, in order to secure ties, piles, and bridge timbers. There are now several large commercial planting operations by corporations and individuals, and it is predicted that 25,000,000 trees will be put out during 1910, and that the quantity will increase from year to year.

The eucalyptus trees reproduce rapidly, from both seed and sprout. The fruiting is moderate during the early growth, but they bear abundantly when older. Seed buttons are often seen on two- or three-year-old trees. There seems to be an impression that there is no reproduction from natural seeding, but this is not true. The seed is so abundant and so easily carried by the wind that any scheme of extensive planting should begin at the higher elevations, from which natural reproduction may proceed down hill into the lower levels.

Of the 150 recognized species, about 100 have been introduced into California, and of these, three have been given the greatest attention. These are commonly known as blue gum, red gum, and sugar gum. Gray, manna, and lemon gums are also favorites, and the six species are all that any planter need consider.

The propagation of the favorite species, blue, sugar, and red gum, is not difficult. The planter may, if he intends

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to operate extensively, propagate in a lath house at a cost of about three dollars per thousand plants. Nurserymen and dealers in eucalyptus seed are found in the principal cities of southern California and as far north as San Francisco. Seedlings may be purchased at from eight to thirty dollars per thousand.

Although the seedlings are not as tender as conifers, they are subject to "damping off." For this reason it is safer to water them about 9 A. M. They may be set in pots, cans, or paper boxes if it is intended to use them for a woodlot or a plantation. One-year-old pot-grown plants are not good for windbreaks, as the roots are liable to be cramped and knotted, and therefore not so strong in furnishing a good roothold.

The best results are obtained by cultivating twice each season for the first two years and to irrigate, if necessary. Some planters cultivate thoroughly without irrigating; others irrigate without cultivating; others simply put out the young trees and allow them to shift for themselves, expecting a loss which may be replaced by a later planting, but which, of course, must be included in the initial cost of the plantation. The best results can be obtained by giving to the young trees as much attention as is given to any other crop, until they are able to take care of themselves. This they should be able to do in two years' time quite as well as if further attention were given them.

Although eucalypts will yield the greater crop on deep, moist soil or adobe, it is fortunate that the physical properties of the soil are the controlling factors, and therefore, large areas lying above possible irrigation are well adapted for raising a profitable plantation. They will thrive even in dry and stony soils, even where the admixture of sand is very scanty.

Young trees may be set out in the winter, and the best time to cut old trees to secure a good sprouting is also in the winter.

The cost of planting eucalypts and the profit which will

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be derived from the plantations have been the subject of widely differing estimates. This is due to the different methods employed, the species used, and the character and value of the soil. There is also to be considered the destruction of very young trees by rabbits. Undoubtedly, the best results could be obtained by using good soil, but the initial value of the land for other crops might properly receive first consideration. In each specific case it would be for the planter to decide whether eucalypts would be the most profitable crop, or whether eucalypts would be the only crop which could be raised upon a certain piece of land. The hilly or mountain areas, with a scanty or irregular covering of soil, interspersed with exposed rock formations, which render it unfit for cultivation, might properly be stocked with eucalypts. On such areas, the baby trees after being set out would be left to shift for themselves, and the planter would expect to replace the 5 or 10 per cent. which would die. Such areas as these are by far the larger problem which must be solved. It is on this problem that our attention should be focused. Even for this class of work the estimates differ widely, ranging from five to twenty-five dollars per acre, according to the number of seedlings planted and the success of the first planting. It would probably be fair to estimate fifteen dollars per acre for setting out 800 trees per acre. If this work were taken up in a systematic manner over a large area, the cost might be reduced to ten dollars. The seedlings for an area can be propagated for two and two and a half dollars and the remainder of the cost is for placing them in the ground and replacing those which die.

It is held that the utilization of eucalypts will solve some of the hardwood problems of the United States, the fuel problem of the Southwest, and several minor problems. In spite of its very rapid growth, the wood is superior to most of the hardwoods and equal to mahogany. There is no use to which wood may be put which some species of eucalypts does not fill, unless it be for butter tubs, well curbing,

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and other uses for which the wood must be without a taint or flavor. The tree is not omnipotent; it can not be both hard and soft at the same time; it can not be fragrant and vermin-proof and yet odorless, any more than it can be immune from fire and yet make good fuel. But within the bounds of reason it is a tree which is not excelled by any other genus. It has been used for inside finish, flooring, furniture, vehicles, shipbuilding, street paving, ties, poles, fencing, and piles.

The eucalypts are resistant to the teredo and other marine worms. In this respect the red gum is considered the best.

It appears, therefore, that the standing tree is good as a forest cover, for windbreaks, and for shade; that its wood may be used for almost all purposes, and that even its leaves and flowers may be utilized. There is no other tree in its class.

Aside from its office as a shade producer, a protector of watersheds and soils, the eucalyptus is a benefactor of man in at least three ways: first, it improves swamp conditions by draining the soil and removing the liability of malaria; second, it yields oils, gums, and resin, which have many medicinal qualities; third, it purifies and perfumes the air. All of these make for antiseptic conditions.

The red gum and some other species contain a large amount of kino, which is a gum similar to the resin of pines. This has a powerful preservative effect on the timber; as an antiseptic it is used for the treatment of ulcers and gangrene, and it is also a deodorizer.

Eucalypt oil is an agreeable antiseptic for all irritation of the mucous membranes. Its effect upon the air is to change it to peroxide of hydrogen. It is used in preparing cough syrups and candies for relieving irritations of the throat; its effect upon the human organism is a general stimulation, favorable to health; it is a curative for diseases of the lungs, and is a tonic.

The balsamic exhalation from the leaves is a purifying agent. When placed among clothes or in closets the leaves

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will prevent moths from laying eggs there; the odor is agreeable, not unlike incense. A decoction from the leaves is used for intermittent fevers. Cases are cited, where quinine has been used without effect, which were cured by eucalyptus, and good results have been obtained from its use in cholera cases. Mixed with albumen and fresh fibrin, the eucalypt oil prevents decomposition. An animal treated with it may be dried and mummified by simple exposure to the air.

The lumber and cordwood of eucalyptus will always bring a high price, because of the scarcity of timber in the Southwest. It is not likely that the supply will ever be so great that the price will decrease. Railway ties are worth at least eighty cents each; wood is worth twelve dollars a cord, and well-seasoned lumber is worth from twenty-five to one hundred dollars per thousand, according to grade.

A comparison with Forest Service tests on hickory shows that thirty-year-old blue gum is stronger than XXX hickory, and that fifteen-year-old sugar gum is nearly as strong as black hickory and 91 per cent. as strong as second-growth hickory.

But the eucalyptus has some disadvantages, not all of which may be overcome or remedied. The effect of the disadvantages which can not be remedied is to restrict the area from which the tree may successfully be grown. It is only fair to say, however, that this area is so large, covering southern California, parts of Arizona, New Mexico, Texas and Florida, that many years must pass before it will be found insufficient. It may also be remembered that northern Mexico, which now is not a timber-producing region will also grow eucalypts.

The hardiness of the species differs. The blue gum may be killed by frost, although the manna gum in the same locality will not be affected. The statement is frequently made that eucalypts can grow where oranges grow. It is also true that eucalypts may be killed where oranges are killed, and this has been demonstrated in Florida. The

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order of the species in their power to resist frost is given by Lull as follows: red, grey, manna, blue, sugar, and lemon gum.

There is danger from fire in eucalyptus plantations. This must be considered as a risk, and it may be considered a disadvantage if one were a eucalyptus speculator trying to sell stock to nonresident investors. On the other hand, it is impossible to imagine a plantation which would make good fuel and yet not burn. It is by no means an inflammable tree at any time of the year and should not be compared with some of the pines or firs which exude quantities of inflammable pitch and resin. The danger to the plantation is from ground fires in the droppings, which may kill the trees because the bark is too thin to offer protection. The result of a ground fire is simply to kill the trees and force the harvesting of a crop. The stumps will again sprout and the growth of the plantation will continue.

It would be foolish to advise everybody to invest in eucalyptus plantations, or to become planters of eucalypts. Caution and knowledge are required, as in other lines of endeavor, and one should use as much sense in tree-growing as in breeding bull pups, and more than is commonly used in raising children. Circular No. 2 gives the necessary instructions for eucalypt planters. It is probable that the industry will increase from year to year. It remains for the Government to plant the timberless areas on the National Forests, and the best time to begin is now.

Bibliography of Eucalyptus

Aberg. Irrigation of Eucalyptus. Buenos Ayres, 1874.

Albert, Federico. El Gomero de mana o Eucalyptus viminalis. Pp. 34, ill., 8°. Santiago de Chile, 1907.

Albert, Federico. La caoba roja, o Eucalyptus resinifera. Por Federico Albert. Santiago de Chile, Imprenta Cervantes, 1907.

Albert, Federico. La caoba de las vegas, o Eucalyptus robusta. Por Federico Albert. Santiago de Chile, Imprenta Cervantes, 1907.

Digitized by Google

ALBERT, FEDERICO. El karri o Eucalyptus diversicolor. Por Federico Albert, jefe de la Seccion de aguas i bosques, Santiago de Chile, Imprenta moderna, 1906.

ANDERSON, JOHN B. The Blue Gum; a Brief Study of Eucalyptus Globulus and Others of the Same Genus in California. Forestry and Irrigation, Vol. 10, pp. 65-70, February, 1904.

ANDERSON, J. B. Growth and value of Commercial Eucalyptus in California. (Office report, season 1903.) 1904. Manuscript report C. P.-Cal. Aba-3.

ANDRADE, E. NAVARRO DE. A Cultura de Eucalyptus. Pp. 156, ill. 1909.

ANDRE, EDWARD. Eucalyptus globulus. pp. 14, 8°. Paris, 1863. Extrait de la Revue Horticole du ler Fevrier, 1863.

Australian Eucalypti in India. Jour. For., 1878-9, Vol. 2, pp. 142.

AYRES, ROBERT W. Report on the Creosoting of Eucalyptus Posts at Ellwood, California. Manuscript report.

BAILEY. Contributions to Queensland Flora. Brisbane, 1896.

BAILEY. Queensland Woods. London. 1899.

BAILEY, L. H. Cyclopedia of American Horticulture. (E-M) 1900. (H. M. Hall.) Gives the botanical characteristics in a brief form. Article written by J. B. Doag.

BAKER, H. D. Eucalyptus Oil. Products of Eucalyptus. U. S. Daily Consular Reports, February 25, 1909, No. 3415, pp. 13-14.

BAKER, RICHARD THOMAS. A Research on the Eucalypts, especially in Regard to their Essential Oils. By Richard T. Baker and Henry G. Smith. Pub. by authority of the government of the State of New South Wales. Sydney, W. A. Gullick, Govt. Printer, 1902.

BARRETT, J. E. Shelter-planting, with Special Reference to the Acacia and Eucalyptus Families and their Raising. Pp. 10, 8°. Wellington, N. Z., 1908. (New Zealand, Dept. of Livestock and Agriculture, Division of, Bulletin 1.)

Beauchamp Eucalyptus, The. Gard. Chron., July 1, 1905, Vol. 38:3, ill.

BENTHAM AND MUELLER. Flora Australiensis. Vol. III. London.

BERTHERAUD. L'Eucalyptus au point de vue l'hygiene en Algerie. Alger. 1876.

BREHM, GEORGE O. Eucalyptus as a Hardwood. (In For. California, November, 1905, Vol. 2, No. 12, pp. 11-13.)

BRUNEL. Sobre el Eucalyptus globulus. Revista medico quirurgico. Buenos Ayres. 1873.

BUIJMAN, M. De eucalyptussoorten. Cultura. February, April, November, December, 1903. Vol. 15, Nos. 175, 177, 185, pp. 70-75, 189-193, 586-587.

Digitized by Google

BUTON. L'Eucalypto. Bologna. 1875.

California—Forestry, State Board of. A Handbook for Eucalyptus Planters. Pp. 48, ill., map, 8°. Sacramento, 1907. (Circular 2.)

CARLOTTI. De la culture de l'Eucalyptus en Corse. Bulletin de la Société d'Acclimatation de Paris. 1866.

CARLOTTI. L'Eucalyptus globulus. Ajaccio. 1870.

CARLOTTI. Assainissement des regions chaudes insalubres par l'Eucalyptus. Ajaccio. 1875.

CARLOTTI. L'Eucalyptus en Corse. Bulletin de la Société d'Acclimatation de Paris. 1877.

CERTEUX, A. Guide du planteur d'eucalyptus. Pp. 251, 1 pl., 8°. Alger, 1877.

COATES, LEONARD. Growing the Eucalyptus. Water and Forest, October, 1907, Vol. 7, No. 3, pp. 13-14.

COMBES, PAUL. L'Eucalyptus et ses derives. Pp. 77, ill., 8°. Paris, 1895.

COOPER, ELLWOOD (compiler). Forest Culture and Eucalyptus Trees. Pp. 277, 12°. San Francisco, Cal., 1876.

CORDIER. Des Eucalyptus. Bulletin de la Société d'Agriculture d'Agen. 1874.

CORDIER. L'Eucalyptus en Algerie. Bulletin de la Société d'Acclimatation de Paris. 1876.

CORNELL, F. D. The Eucalyptus Industry. Ill. (In Grizzly Bear, April, 1909, Vol. 4, No. 6, pp. 10-11.)

CORNELL, F. D. A Great Industry Promised for California. (In Grizzly Bear, September, 1908, Vol. 3, No. 5, p. 4.)

CORNELL, F. D. Eucalyptus Planting in California. Read at the eleventh annual meeting of the Counties Committee of the California Promotion Committee, May 8, 1909.

CRAFTS, H. A. The Eucalyptus of California. Ill. Woodw. Rev., Dec., 1908, Vol. 6, No. 11, pp. 436-437.

DARWIN, CHARLES. Power and Movement of Plants. 1881. (Oakland Library.)

DEANE, HENRY, and MAIDEN, J. H. Further Notes on Supposed Hybridization amongst Eucalypts (including a description of a new species). Sydney, 1901.

DEANE, HENRY, and MAIDEN, J. H. Observations on the Eucalypts of New South Wales. Parts 1-3, pl., 8°. Sydney, 1895-97.

DEANE, HENRY, and MAIDEN, J. H. Observations on the Eucalypts of New South Wales. Proceedings of the Linnean Society of New South Wales. 1895-1902.

DEANE, HENRY, and MAIDEN, J. H. On a New Species of Eucalyptus from the Sydney District. Pp. 3, 1 pl., 8°. Sydney, 1897. From Proceedings of the Linnean Society of New South Wales, 1897. Pp. 561-563.

Digitized by Google

DEILS, L. A Few Remarks Concerning the Forests of the Jarrah, Eucalyptus Marginata and Other Species of Eucalyptus. Ind. For., January, 1905, Vol. 31, pp. 19-23.

DODSON, J. H. Description of the Various Experiments in Planting Several Species, with the Success of Each. (1894-1903), 1903. Manuscript report C. P. Cal. San Die.-1.

DODSON, J. H. Report in Letter Form on Experiment in Growing 34 Varieties of Eucalypts. 1907. Manuscript report C. P. Cal. San Die.-1 1.

DOUGLAS, THOMAS H. List of 13 Species of Large Size. California State Board of Forestry, 1887-88, p. 40.

DRAPER, H. N. Eucalyptus in the Roman Campagna. Popular Science Monthly, 1881, Vol. 19, pp. 94-100.

EDNIE-BROWN, J. The Forests of Western Australia and their Development. 1899. (University of Cal. Library.) Describes the principal eucalypts in W. A., as Jarrah, Karri, Tuart, Yate, Gum, Red Gum, etc.

Eucalypti as Timber Trees. Popular Science Monthly, 1876, Vol. 9, p. 509.

EUCALYPTS. Forest Service circular 59 (revised), 1907.

Eucalyptus. Three booklets by the Eucalyptus Timber Corporation.

Eucalyptus. U. S. Consular Report, 1887, Vol. 23, pp. 12-13.

Eucalyptus. (In U. S. Dept. of Agriculture Report, 1877, p. 51.)

Eucalyptus. List of Species Recorded as Cultivated in the Open Air in British Gardens. Gard. Chron., July 1, 1905, Vol. 38:13.

Eucalyptus. Two articles on Eucalyptus. Forest Service letter files.

Eucalyptus Corymbosa. Notes on Eucalyptus Corymbosa in California. Gard. and For., 1896, Vol. 9, p. 474.

Eucalyptus Diversicolor. Australian hardwood combination. Amer. Lum., August 16, 1902, No. 1421, p. 14.

Eucalyptus Forest in Southern California. (In U. S. Dept. of Agriculture Report, 1875, p. 345.)

Eucalyptus for Fuel. For. and Irrigation, Aug., 1903, Vol. 9, p. 373.

Eucalyptus for the South. Arboriculture, February, 1903, Vol. 2, pp. 145-147.

Eucalyptus Globulus. Australian Blue Gum for Harbor Piles. So. Lum., April 10, 1905, Vol. 47, No. 539, p. 18.

Eucalyptus. (In U. S. Forest Service, Dept. of Agric.) Annual Report, 1887, pp. 92-94.

Eucalyptus Globulus. Australian Fever Tree. Popular Science Monthly, 1875, Vol. 7, pp. 344-348.

Eucalyptus Globulus. Eucalyptus Globulus in California. Gard. Month., 1874, Vol. 16, p. 251.

Eucalyptus Globulus. Eucalyptus. Ill. Hdw. Rec., July 10, 1907, Vol. 24, No. 6, pp. 16-17.

Digitized by Google

Eucalyptus Globulus. Eucalyptus Globulus in California. (In U. S. Dept. of Agriculture Report, 1880, p. 612.)

Eucalyptus, The, in Mexico. Arbor., August, 1903, Vol. 2, pp. 286-287.

Eucalyptus in South Africa, The. (In Jamaica-Dept. of Agric.) Bulletin, January, 1904, Vol. 2, Pt. 1, pp. 12-13.

Eucalyptus in Sussex. Jour. For., 1878-9, Vol. 2, p. 589.

Eucalyptus Maculata. New South Wales, Dept. of Agric. Spotted Gum Committee. Report on the Spotted Gum with Special Reference to its Value for Wood-paving. Ed. 2, pp. 46, 8° Sydney, 1897. From Agric. Gaz. of New South Wales, April, 1896.

Eucalyptus Marginata. Resistance of the Australian Jarrah Wood to Fire. Ind. For., September, 1903, Vol. 29, pp. 425.

Eucalyptus Marginata. Australian Hardwood Combination. Amer. Lum., August 16, 1902. No. 1421, pp. 14.

Eucalyptus Marginata. Australian Timber Resources. Ill. Timberman, January, 1909. Vol. 10, No. 3, pp. 66-67.

Eucalyptus Marginata. An Australian Wood. Pacific Coast Wood and Iron, March, 1902, Vol. 24.

Eucalyptus Marginata. Jarrah Ties, Interoceanic Railway of Mexico. Ry. and Eng. Rev., January 5, 1901. Vol. 41, p. 9.

Eucalyptus Marginata. Lumbering in West Australia. Col. River and Oregon Timbermen, May, 1903, Vol. 4, No. 7.

Eucalyptus Occidentalis. Analysis of Mallet Bark. Natal Agr. Journal and Min. Rec., 1905, Vol. 8, pp. 578-80.

Eucalyptus Planted by Southern Pacific Railroad. (In U. S. Dept. of Agriculture, Div. of Forestry, Bul. 1, p. 27-8.)

Eucalyptus Rostrata. Plant Forest of Trees. Wood and Iron, Vol. 40, No. 3, p. 21, September, 1903.

Eucalyptus Trees. Ind. For., April, 1908, Vol. 34, pp. 197-200.

Eucalyptus Tree in California. Jamaica Bot., Dept. Bul., 1896, N. S., Vol. 3, p. 149.

Fedeli. Sulle proprieta bonificante et terapeutiche del l'Eucalyptus Globulus. Forli. 1876.

Fernow, B. E. Economics of Forestry. 1902. (U. C. Lib.) Sanitary Influence of E. Pp. 77. Forest Policy of Australia in regard to E. Pp. 289-90. Short references.

Flintham, S. J. Forest Planting in the Mountains of California. (In coöperation with the State.) (Yellow pine, Eucalypts.) 1907. Manuscript report, C. P.-Cal. Aba-7.

Flintham, S. J. Growth and Utilization of the Commercial Eucalypts in California. 1907. Manuscript report, C. P.-Cal. Aba-5.

Digitized by Google

FLINTHAM, S. J. Report of an Examination of the Cut-over Lands of the Union Lumber Company, Mendocino County, California, 1907. Manuscript report, C. P.-Cal. Men.-1.

Forestry Society of California. Uses for Eucalyptus Lumber and Timber. Pp. 12, 8°. Los Angeles, 1908. (Bulletin 3.)

Forestry Society of California. Value of Eucalyptus Trees. Pp. 4. 8°. Los Angeles, 1908. (Bulletin 4.)

FROITZHEIM, C. Australian Hardwood. Glaser's Annalen. January 1, 1905.

GASKILL, ALFRED. Eucalyptus on the Roman Campagna. Forest Leaves, February, 1903. Vol. 9, p. 11.

GASTINEL-BEY. Memoire sur l'Eucalyptus globulus d'Australie. L'Egypte Agricole. 1870.

GAYE, SELINA. The Great World's Farm. 1894. (Oakland Lib.) Short reference.

GIFFORD, JOHN. Eucalyptus in the Tropics, its Rapid Growth and Value as a Sanitary Agent, Acting as a Preventative of Malaria. Forestry, January, 1900, Vol. 6, pp. 11-13.

GIFFORD, JOHN. Practical Forestry. 1902. Short references. E. in California, pp. 17, 73; Moisture demanded by, p. 61; Sanitary Influence of, p. 66; Method of Growing, p. 128; Value of, p. 220; E. diversicolor, p. 42; E. rostrata, p. 95.

GILDAS. L'Eucalyptus dans la Campagne Romaine. Bulletin de la Société d'Acclimatation de Paris. 1875.

GILLESPIE, T. J. The Eucalyptus Industry. Ill. Overland Monthly, April, 1909, N. S., Vol. 53, pp. 359-60.

GIMBERT. Etude sur l'Influence des Plantations d'Eucalyptus Globulus. 1875.

GIMBERT. L'Eucalyptus globulus; son importance en agriculture, en hygiene, en medicine. Paris, 1870.

GRIFFON, E. Recherches sur la transpiration des feuilles d'eucalyptus. Contes rendus de l'acad. des sci., 1903. Vol. 138, pp. 157-9.

HALL, WM. L. Notes on Success of Boxelder, Monterey Cypress, and Eucalyptus in Central California. 1901. Manuscript Report, C. P.-Cal. Aba-1.

HAMM, WILHELM VON. Der fieberheilbaum oder blau-gummibaum. (Eucalyptus globulus.) Ed. 2, rev. and enl., pp. 55, 16°. Wien, 1878.

Hardwood, the Eucalypti. Water and Forest, July, 1907, Vol. 7, No. 2, p. 13.

HIMELY, H. A. Letter on Growth of Eucalyptus in Cuba. Forest Service letter file.

HOMEYER, IGNAZ. Ueber die blätter von Eucalyptus globulus und deren ätherisches oel, Halle, Buchdruckerei des Waisenhauses, 1874.

Digitized by Google

HOUGH, FRANKLIN B. Elements of Forestry, 1882. (U. C. Lib.) Pp. 264. Eucalyptus. Short reference.

How to Grow Eucalyptus. Southwestern Stockman, July 10, 1908, p. 1.

HUNT, L. E. Progress Report on the Strength of Eucalyptus Grown in California. 1906. Manuscript Report.

HUSMANN, SR., G. Forestry in California; Notes on Early Introduction of Eucalyptus Globulus, and Rate of Growth with Money Returns, etc., 1901. Manuscript report, R.-Cal. Nap-1.

HUTCHINS, D. E. Eucalyptus Occidentalis: Mallet Eucalypt Bark Better than Black Wattle. Agr. Journal Cape Good Hope, 1905, Vol. 26, pp. 784-9.

INGHAM, NORMAN D. Eucalyptus in California. Pp. 88, Ill., 8°. Sacramento, 1908. (California Agricultural Experiment Station, Bul. 196.)

Ironbark. Agr. Gazette, N. S. W., 1895, Vol. 6, pp. 821-4.

JOLY, CHARLES. Note sur les eucalyptus geants de l'Australie. Pp. 19, 4°. Paris, 1885.

JULIUS, G. A. Western Australia Timber Tests. 1906. (L. E. Hunt.)

KINGZETT, G. T. Nature's Hygiene; a Series of Essays on Popular Scientific Subjects, with Special Reference to the Chemistry and Hygiene of the Eucalyptus and the Pine. Pp. 192, 8°. London, 1880.

KINNEY, ABBOT. Eucalyptus. Pp. 298, ill., 8°. Los Angeles, Cal., 1895.

KINNEY, ABBOT. Eucalyptus. Pp. 6. Washington, 1895. (U. S. Department of Agriculture, Div. of Forestry Bul. 11, pp. 23-28.)

KINNEY, ABBOT. Letter. Forest Service letter file.

LAMBERT. Eucalyptus: culture, exploitation, et produit. Bulletin de la Société d'Acclimatation de Paris. 1872.

LASLETT, THOMAS. Timber and Timber Trees. (U. C. Lib.) 1875. Pp. 187. E. in Australia. Short reference.

LIGNIER, O. Essai d'acclimatation a Caen de l'Eucalyptus urnigera. Bull. d. l. Soc. Linneenne de Normandie, 1902, Vol. 6, pp. 145-151.

LOCKWOOD, SAMUEL. Eucalyptus in the Future. Popular Science Monthly, 1877-78, Vol. 12, pp. 662-71.

LUEHMANN, J. G. A Short Dichotomous Key to the Hitherto Known Species of Eucalyptus. 1908. Australian Soc. for Adv. of Science. (U. C. Lib.)

LULL, G. B. The Eucalyptus Situation in California. Grizzly Bear, March, 1909, Vol. 4, No. 5, p. 1.

LULL, G. B. A Handbook for Eucalyptus Planters. Circular 2, 1908.

Digitized by Google

LYNE, CARMICHAEL. Tasmanian Timbers: Their Qualities and Uses. 1903. (L. E. Hunt.)

LYON, WILLIAM S. Report on the Growth of Some Species of Eucalyptus in Southern California. P. 8. Los Angeles, 1889. (California-Forestry Bul. 6.)

M., J. C. Growing the Eucalyptus. Water and Forest, July-October, 1906, Vol. 6, No. 2-3, p. 4.

MAIDEN. The Forest of New South Wales. Agricultural Gazette of New South Wales. 1901.

MAIDEN. Notes on the Commercial Timbers of New South Wales. Sidney, 1895.

MAIDEN. Useful Australian Plants. Agricultural Gazette of New South Wales. 1893-1900.

MAIDEN, J. H. Useful Native Plants of Australia. 1889. (H. M. Hall.) Giving a short review of the different species.

MAIDEN, J. H. A Critical Revision of the Genus Eucalyptus. (H. M. Hall.) Part I, 1903; Part II, 1903; Part III, 1903; Part IV, 1904; Part V, 1904; Part VI, 1905. A botanical treatise.

MAIDEN, JOSEPH HENRY. A Critical Revision of the Genus Eucalyptus, by J. H. Maiden. Parts 1-10. Sydney, W. A. Gullick, gov't printer, 1903-7.

MAIDEN, J. H. Miscellaneous Notes (chiefly taxonomic) on Eucalyptus. Proc. Linn. Soc., N. S. W., 1905.

MAIDEN, J. H. Further Notes on Hybridization in the Genus Eucalyptus. Proc. Linn. Soc., N. S. W., 1905.

MAIDEN, J. H. The Variability of Eucalyptus under Cultivation. Proc. Linn. Soc. N. S. W., 1903, Vol. 28, pp. 887-903.

MAIDEN, J. H. Description of Two Victorian Eucalypts. Pp. 5, 8°. Melbourne, 1904. From the Victorian Naturalist, Vol. 21, No. 8, December 8, 1904.

MAIDEN, JOSEPH HENRY. Is Eucalyptus Variable? Pp. 26, 8°. Sidney, 1902. Reprinted from Journal and Proceedings of the Royal Society of New South Wales, Vol. 36.

MAIDEN, J. H. Miscellaneous Notes (chiefly taxonomic) on Eucalyptus. Part 2, 8°. Sydney, N. S. W., 1906. From Proc. of the Linn. Soc. of New South Wales, 1905, part 4, November 29.

MAIDEN, JOSEPH HENRY. On the Occurrence of Eucalyptus Dives, Schauer, in Victoria. Pp. 7, 8°. Sydney, 1901. (Victorian Naturalist, December 5, 1901, Vol. 18, No. 8, pp. 124-30.) Read before the Field Naturalists' Club of Victoria, November 18, 1901.

MAIDEN. J. H. On Hybridization of the Genus Eucalyptus. Pp. 7, 8°. Wellington. 1905. Extract from Transactions of Australian Association for the Advancement of Science, January, 1904.

MAIDEN, J. H. Eucalyptus Longifolia. Useful Australian Plants. Agr. Gazette, N. S. W., 1896, Vol. 7, pp. 259-61.

Digitized by Google

McCLATCHIE, ALFRED JAMES. Eucalypts Cultivated in the United States. Pp. 106, 92 pls., 4°. Washington, 1902. (U. S. Agri. Dept., Bureau of Forestry Bul. 35.)

McCLATCHIE, A. J. Eucalypts of the Southwest. Ill. Outwest. April-May, 1904, Vol. 20, pp. 336-46, 422-35.

MACMAHON, PHILIP. Eucalyptus Timbers in South America (in his Australian forest question condensed). 1904, pp. 2-3.

Malaria and the Eucalyptus. Popular Science Monthly, 1885, Vol. 27, pp. 356-7.

DE MARAFY, MAILLARD. L'Eucalyptus: Nouvel Emploi Industriel. L'Egypte Agricole. 1870.

MARES. Note sur l'Eucalyptus. Alger. 1870.

MARES. Notes on the Commercial Timbers of New South Wales, Sidney, 1895.

MARES. The Forest of New South Wales. Agr. Gazette of New South Wales. 1901.

MEAUME, E. L'Eucalyptus à la colonie agricole des Trois-Fontaines pres Rome. Pp. 36, 4°. Paris, 1882. Extrait de la Revue des eaux et forêts.

MENOY, K. G. The Eucalyptus (E. Globulus) Oil Factory of Coonoor, Nilgiris. Ill. Ind. Forester, July, 1905, Vol. 31, pp. 375-6.

MERICE. Progres et development de la culture de l'Eucalyptus. Bulletin de la Société d'Acclimatation de Paris. 1874.

MERRILL, A. P. Forestry in Australia. Report of Vice-Consul General at Melbourne, Australia, to Assistant Secretary of State. Manuscript report, M.–Gen. Aus.–1.

MIELKE, G. Anatomische und physiologische beobachtungen an den blättern einiger Eucalyptus-arten. Pp. 27, 8°. Hamb., 1892.

MONCHALAIT. Eucalyptus. Bulletin del a Société d'Acclimatation de Paris. 1867.

MORALES, D. BALBRINO. Manuel de Cultivo del Eucalipto. 1883.

MUELLER, FERDINAND, FREIHERR VON. 1825-1896. Eucalyptographia. A Descriptive Atlas of the Eucalypts of Australia and the Adjoining Islands; by Baron Ferd. von Mueller. Melbourne, J. Ferres, gov't printer, 1883.

MUELLER. Fragmenta phytographiæ Australiae. Melbourne, 1858-1875.

MUELLER. Australian Vegetation, Indigenous and Introduced. Melbourne. 1866.

NANGLE, J. Transverse Tests of Jarrah, Eucalyptus Marginata, made at Sydney Technical College. Pl. Journal and Proc. Royal Society N. S. W., 1906, Vol. 40, pp. 101-3.

Digitized by Google

NARDY. Les Eucalyptus du littoral de la mediterranée. Journal. de la Société Centrale d'Horticulture de France. 1875.

NAUDIN. Les Eucalyptus introduits dans la region mediterranéenne Antibes. 1883.

NAUDIN. Description et emploi des Eucalyptus introduits en Europe. Antibes. 1891.

Notes on Eucalyptus Planted at the Monastery of Tre Fontane, Roman Campagna. Forest Service letter file.

PASQUIER. De l'Eucalyptus Chateau-Gontier. 1873.

PERRIN, GEORGE S. Eucalypts and Decorative Woods of Tasmania. Pp. 7. f°. Tasmania, 1886. Tasmania-Forests, Conservator of. Publications.

PHILLIPE. Sur l'Eucalyptus Globulus. Bulletin de la Société d' Acclimatation de Paris. 1862.

PIETRA-SANTA. Influence de l'Eucalyptus en Algerie et en Corse. La Nature. 1877.

PLANCHON, JULES EMILE. L'Eucalyptus Globulus au point de vue botanique, economique et medical. Extrait de la Revue des deux mondes, livraison du 1 janvier 1875. Paris, Impr. de J. Claye, 1875.

PLANCHON, JULES EMILE. Eucalyptus Globulus, from a Botanic, Economic, and Medical Point of View, Embracing its Introducduction, Culture, and Uses; translated from the French. Pp. 20. I pl. 8°. Washington, 1875. (U. S. Dept. of Agriculture. Publication.)

PLAYFAIR. Culture of Eucalyptus in Algeria. Journal Forestry, 1877-78, Vol. 1, pp. 363-70.

PLUMMER, FRED G. Practice of Forestry at Point Loma, Calif. 1905. Manuscript in Forest Service.

PLUMMER, FRED G. Progress of Planting at Point Loma, Calif. Map and table. 1909.

PLUMMER, FRED G. Advice on Planting Eucalypts. San Diego News, 1907.

PLUMMER, FRED G. The Growing of Eucalypts. Proceedings Soc. of Amer. Foresters, Vol. v, No. 1.

POLLI. Sull' Eucalipto. Milano. 1876.

Possibilities of Profit in Growing Eucalypti. Am. Lumberman, May 2, 1908, No. 1719. P. 37.

Railroad Eucalyptus Plantation in Southern California for a Future Timber Supply. Am. Lumberman, Feb. 15, 1908, No. 1708, p. 33.

RAMEL. Sur les Eucalyptus oleosa et globulus. Bulletin de la Société d'Acclimatation de Paris. 1861.

RAMEL. L'Eucalyptus globulus de Tasmanie. Revue maritime et coloniale. 1861.

Digitized by Google

RAMEL. L'Eucalyptus globulus. Bulletin de la Société d'Acclimatation de Paris. 1862.

RAVERET-WATEL, M. C. L'Eucalyptus: Rapport sur son introduction, sa culture, ses propriétés, usages, etc. Bulletin de la Société d'Acclimatation de Paris. 1871, 1872.

RAVERET-WATTEL, M. C. 1875. (U. C. Lib.) General Description of the Species; Their Distribution in the Different Countries.

RAVERET-WATTEL, M. C. L'Eucalyptus et son avenir. Bulletin de la Société d'Acclimatation de Paris. 1873.

ROGERS, JULIA ELLEN. The Tree Book. 1907. (U. C. Lib.) Eucalyptus Plantations, p. 474.

ROYER, A. Les eucalyptus. Rev. hort. Tunisienne, October, 1906-January, 1907, No. 22, pp. 207-16; No. 23, pp. 271-7; No. 24, pp. 52-6; No. 25, pp. 95-9.

SAHUT, FELIX. Les eucalyptus; aire geographique de leur indigenat et de leur culture; historique de leur decouverte; description de leurs propriétés forestières, industrielles, assainissantes, medicinales, etc., guide de leur culpellier, 1888.

SAWTELLE, B. L. Eucalyptus, Future Timber for Producers in this State. Ill. (In Orchard and Farm, April, 1908, Vol. 7, No. 4, pp. 5-6.)

SCAMMELL, ED. T. Timber Resources of the Australian Commonwealth. Journal Society of Arts. May 2, 1902.

SCUSA-PIMENTEL. Eucalypto Globulus; descripcao, culture approveitamento d'esta arvore. Lisboune. 1884.

SELLERS, C. H. Eucalyptus, a Substitute for Eastern Hardwoods. Ill. Overland Magazine, May, 1909, N. S., Vol. 53, pp. 446-51.

SHEPSTONE, HAROLD J. The Tasmanian Blue Gum, an Ideal Timber for Harbor Building. Ill. Scientific American, January 21, 1905, Vol. 92, No. 3, pp. 43-44.

SMITH, C. STOWELL, Utilization of Eucalyptus. Overland Monthly, August, 1909.

SMITH, H. G. The Eucalypts of Australia. Scientific American supplement, November 30, December 7, 1907, Vol. 64, No. 1665, pp. 350-1; No. 1666, pp. 367-8.

SMITH, H. J. On the Occurrence of Calcium Oxalate in the Barks of the Eucalypts. Jour. and Proc. Royal Society N. S. Wales, 1905, Vol. 39, pp. 23-32.

STEARNS, R. E. C. Eucalyptus in the Philippines. Science, October 2, 1903, Vol. 18, pp. 439-40.

STEARNS, R. E. C. On the Economic Value of Certain Australian Forest Trees and their Cultivation in California. Pp. 11. 8°. N. P. 1872. From the Proceedings of the California Academy of Sciences. July 1, 1872.

Digitized by Google

STIRLING, JAMES. Notes on the Genus Eucalyptus-Economic Uses. Edinb. Bot. Soc. Trans. and Proceedings, 1904, Vol. 22, Pt. 3, pp. 334-8.

Strange Facts about the Eucalyptus. Maxwell's Talisman, November, 1903, Vol. 3, No. 4, p. 12.

Subhardy Eucalyptus. Gard. Monthly. 1876, Vol. 18, p. 147.

TAYLOR, ANDREW. Eucalyptus of Australia. Jour. For., 1880-81, Vol. 4, pp. 105-7.

THORNBER, J. J. Resistant Eucalypts for Planting in Southern Arizona. 4 pp. 16° N. P. 1908. (Arizona-Agricultural Experiment Station. Timely Hints for Farmers, No. 68.)

TRABUT. Quelques eucalyptus hybrides dans la region Mediterranee. Rev. hort., Vol. 75, pp. 325-28, July 16, 1903.

TROTTIER. L'Eucalyptus; de l'accroissement et de la valeur progressive de l'eucalyptus. Pp. 16. 16°. Alger, 1871.

TROTTIER. Boisement dans le desert et colonisation. Alger, 1869.

TROTTIER. De l'accroissement et de la valeur progressive de l'Eucalyptus. Alger, 1871.

TROTTIER. Arbres de l'Australie. Alger, 1872.

TROTTIER. Rôle de l'Eucalyptus en Algerie. Alger, 1876.

United States–Agriculture, Dept. of–Forest Service. Forest Fires; Eucalyptus, Tree of the Deserts; Timber Tests of Native Trees. Broadside. Washington, 1902. (Press bulletin 22,)

United States–Agriculture, Dept. of–Forestry, Bureau of. Eucalypts. 6 pp. 8°. Washington, 1905. (Forest planting leaflet No. 6.)

United States–Agriculture, Dept. of–Forest Service. Eucalypts for Timber. 2 pp. 4°. Washington, 1906. (Trade bulletin 8.)

Use and Growth of Eucalypts. Lum. Rev., January 1, 1908, Vol. 18, No. 1, p. 16.

VALLEE, AUGUSTE. Culture de l'Eucalyptus aux Trois-Fontaines (pres Rome). Ed. 2, pp. 30, 16°. Landerneau, 1882.

Value of Australian Gum Wood. Gard. Monthly. 1876, Vol. 18, p. 86.

VON MUELLER, FERDINAND, BARON. Eucalyptographia. Melbourne. 1879-84. (U. C. Lib.)

WARD, MARSHALL. Trees. A Handbook of Forestry Botany. 1904. (Oakland Lib.)

WARREN, W. H. Australian Timbers. 1892. (L. E. Hunt.)

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FORESTS AS GATHERERS OF NITROGEN

TREADWELL CLEVELAND, JR.

Presented before the Society March 31, 1910

It has been known for some time that forests, unlike most other crops, add to the soil more nitrogen than is removed in the harvested product. This fact is of great importance in agriculture, because nitrogen is one of the three principal soil elements required by agricultural crops, while the use of artificial fertilizers in the forest is impracticable. Recent investgations appear to indicate that the ability of forests to gather nitrogen is partly due to the ability of the trichomes of plants to assimilate free atmospheric nitrogen.

The importance of the nitrogen question in agriculture is shown by the statements made within recent years by Sir William Crookes, to the effect that the future of the human race depended upon the discovery of an available nitrogen supply. Such a supply has been since discovered in the atmosphere, from which nitrogen is now secured for agricultural use by several commercial processes. It is no longer probable that agriculture will have to face a real nitrogen famine. Nevertheless, however produced, artificial nitrogen costs money, and its use on a large scale is contrary to the ideal of a self-sustaining agriculture. Consequently, though it has been estimated that there is enough nitrogen in the atmosphere over every acre of ground to meet the requirements for the production of a hundred bushels of corn every year for seven hundred thousand years, the cost of converting this atmospheric nitrogen to use still renders most desirable the substitution of natural or agricultural methods in adding nitrogen to the soil. This fact makes the use of leguminous crops in rotation one of the fundamental principles of intensive agriculture. In a

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rough way, the forests may be compared to the legumes in agriculture, since they offer a valuable crop in themselves and at the same time enrich the soil with nitrogen.

In order fully to understand the function of the forest as a nitrogen gatherer, the sources of nitrogen and the use that is made of it by crops in general must be briefly reviewed. Nitrogen differs from the two other chief mineral elements of the soil used by plants in that it is not native to the soil, but is derived from the atmosphere. It reaches the soil in three ways:

1. From combined nitrogen deposited in the soil by precipitation.

2. Nitrogenous matter deposited on the soil by plants and animals.

3. Free nitrogen fixated by living plants, by dead organic matter, and by the mineral elements of the soil.

The soil loses nitrogen in the following ways:

1. By the removal of the crop in which it is stored.

2. By the leaching and drainage of nitrogen not retained by the soil cover.

3. By the return to the air of free nitrogen during the various processes of organic decay.

The result of ordinary agriculture is that the soil is steadily robbed of nitrogen by the removal of crops. In the forest, however, the soil gains more nitrogen than it loses. This is due to the fact that the losses of nitrogen are less, while the gains of nitrogen are more, under forest cover.

To consider the losses first: Forest soil does not lose by leaching and drainage, because only nitrates are thus lost, while nitrification does not take place in forest soil. It is not yet completely understood why nitrates are not formed; but it may be either because there are no nitrous or nitric ferments, or because denitrifying bacteria are present.

Experiment has shown that the removal of the forest crop takes from the soil in the long run about nine pounds

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of nitrogen per acre per year. This loss, however, has been shown by experiment to be not quite offset by the gain in nitrogen due to precipitaton.

Turning now to the gains of nitrogen in forest soil: It has been shown that dead leaves deposit on the forest soil from twenty-seven to forty-five pounds of organic nitrogen per acre per year. This, however, is not an addition but simply a restitution; it is not even a complete restitution, because a notable part of the nitrogen in the leaves migrates from them into the wood in the autumn, and because the organic nitrogen compounds, during the many chemical and biological transformations, give off a certain quantity of free nitrogen to the air.

Leguminous plants add to the nitrogen content of forest soils where present, but their addition is in any case small, and the increase of soil nitrogen under forest cover is conspicuous where leguminous plants are altogether wanting.

Thus far, therefore, the marked gains made by forest soils in nitrogen are unexplained. The first explanation was made by Professor Henry, of the Nancy National School of Forests and Waters, in France (1894 to 1899), who showed by experiments that dead leaves, especially when they lie upon a substratum of humus, possess the power of fixating a notable quantity of atmospheric nitrogen. In 1907 Professor Henry made further contributions to this subject (*Journal d'agriculture pratique,* 1907, tome 1, pages 549-580, 645-678), of which the following is a brief summary:

He found that a plantation of *Pinus maritima,* which had been growing on pure sand since 1850, had accumulated in fifty-six years 240 pounds of nitrogen per acre, or at the rate of 4.5 pounds per acre per year, in addition to the nitrogen utilized in tree growth.

He experimented with *Pinus maritima* and *Pinus laricio* by planting seedlings in fine white sand, placed 4.7 feet deep in an excavation 96.9 square feet in area, and studying the soil under the accumulated litter after the lapse of ten

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years. This test showed that nitrogen had been gathered by the trees to the amount of sixty-four pounds per acre, or at the rate of 7.1 pounds per year.

Even more striking results were obtained by Professor Henry from the study of long-established forests. He found that the soil under an old oak stand near Nancy had stored 6,569 pounds of nitrogen per acre in the soil that was within reach of the tree roots—a nitrogen content that is scarcely equalled and very rarely exceeded by artificially fertilized agricultural soil. (See also his *"Sols forestiers."*)

The theory that plants are able to assimilate free atmospheric nitrogen by means of their trichomes was first advanced by Professor Jamieson, of the Agricultural Research Association, of Aberdeen, Scotland. Professor Jamieson investigated several forest trees, among which were *Acer campestris, Tilia europæa, Ulmus campestris, Sorbus aucuparia, Fagus silvatica* and *Picea concolor.*

The result which he obtained aroused the interest of two foresters at the Royal Hungarian Forest Experiment Station at Selmecbánya, Drs. G. Zemplén and J. Roth, who followed the same methods as Jamieson and secured results which entirely corroborated his. Like Jamieson, they found that the trichomes responded to the ordinary chemical reagents used to detect the presence of nitrogen; that the reaction is stronger with broadleaf trees than with conifers, and that the presence of nitrogen is first detected in the heads of the trichomes, where active growth is taking place. Their report was published in the experiment station periodical entitled *Erdészeti Kisérletek,* 1908, parts 1 and 2, and has since been summarized in German and French translations. It was accompanied by color plates, showing the various forms and colorings assumed by the trichomes investigated.

The conclusions reached by these investigators are not final. They do not assert that the rôle played by the trichomes has been finally determined, and they admit that a great deal of careful work will have to be done to clear

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up points which still remain in doubt. They maintain that the trichomes perform some physiological function, because this is proved by the chemical tests. They point out that the theory advanced by Boussingault, that plants can not assimilate free atmospheric nitrogen, has not been proved; that a great deal of doubt still exists as to the exact manner in which the plants fixate nitrogen; and that the nitrogen content of soils is not only maintained, but is steadily increased to an extent not perhaps wholly accounted for by known factors. For these reasons they hold Jamieson's theory, that the trichomes make atmospheric nitrogen available to plants, to be highly plausible.

As far as the author knows, the experiments conducted by Jamieson, Zemplén, and Roth do not exclude the possibility that the presence of nitrogen in the heads of the trichomes may be due, not to the assimilation of atmospheric nitrogen, but to the decomposition of proteids brought into the trichomes from other parts of the plant.

This whole discussion revives a controversy of long standing among botanists, as to the ability of plants to assimilate atmospheric nitrogen, and gives fresh interest to the study of the functions of the trichomes. Hitherto, among leading botanists, Boussingault held that plants could not assimilate atmospheric nitrogen; R. Hartig held that trees might possibly do so; Potonié and Frank decidedly believed that certain plants had this power, and Frank went so far as to say that all plants had it. Thus, except for Frank, Jamieson was the first to take a position exactly opposed to that of Boussingault. As regards the function of the trichomes, it has been supposed that their main purpose was to protect the plants from excessive heating and cooling and from desiccation, and to protect the buds from pressure, etc.; in short, that they played a purely physical rôle. If, however, the Scotch, German, and Hungarian investigators are right, the trichomes play a very important part in the physiology of plant life.

Not the least interesting aspect of these investigations

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is that they confirm the old popular belief that forests are enrichers of the soil. Common observation has anticipated these results, as it has so many others. Thus, the value of rotations containing legumes was widely recognized long before the activity of legumes as nitrogen gatherers was understood, or even suspected.

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BASKET WILLOW CULTURE IN GERMANY

C. D. MELL

Contributed

Introductory

Americans still have far to go in intensive cropping before they will get the most from their farm lands. For example, there are, on most American farms, waste places—odd corners that do not grow anything of value—rocky, upland thickets that are growing worthless brush instead of valuable timber, or low areas which, when properly drained, could, for example, be growing basket willows.

The main object of this article is to show, through the example furnished by Germany, the advantages of intensive basket willow culture in the United States. It is not intended to give actual instruction in growing basket willows, but to point out that, in the general trend toward national thrift, which depends so much on agricultural methods, there is ample opportunity for farmers in many sections of the country to add to their income by the cultivation of a basket willow holt on land that is now lying idle. These smaller opportunities were often lost sight of in the general desire to grow crops on a large scale, with the thought that there will be correspondingly large returns. Americans are apt to overlook the combined results from many small crops that can be handled with comparatively small expense. The European farmer keeps a strict account of these, and in the aggregate reaps a rich reward for his thrift.

In Germany, basket willow culture is on a high plane, and fairly represents the best results which European growers have attained. Because of that country's high rank, an investigation of willow culture in Germany was made during

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the summer of 1907. This investigation aimed to get information that would enable the American grower to form an intelligent view of the methods used abroad, with the idea of adapting them to American conditions. Basket factories were visited to find out what wares are most commonly manufactured and what grades of stock are used in the different wares. An investigation was also made of the yield of tannin from various willow barks, a source of income not yet taken into account in this country.

A Representative Willow Holt

One of the best managed holts in the Rhine Valley is near Cologne. Fifteen years ago the owner planted sixty varieties of basket willow, to determine those best suited to his land. After several years of experimenting, the poorer varieties were gradually discarded until, at present, only eight varieties remain. Of these not more than five are generally considered desirable in this part of Germany for the manufacture of high-grade ware. The holt comprises fifty acres, which is about one-eighth of the entire farm. The willows are managed under a system of rotation with the regular farm and fruit crops. The holt is kept stocked from ten to fifteen years, depending upon the variety of willows, character of the soil, and general health of the stools. When diminished height-growth shows that the willow crop is beginning to deteriorate, the stools are immediately dug out and the area is seeded to wheat, oats, or potatoes for several years, after which it is again planted to willows. Proper rotation is practiced not only with the ordinary farm crops, but also with the different varieties of willows. An example of rotation is given below:

CROP	ROTATION
Purple willow	1889-1899
Oats	1899-1900
Wheat	1900-1901
Grass	1901-1903
Common white osier	1903-

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Soil and Situation

Soil yielding a fair crop of wheat or oats produces merchantable willow rods, provided the water level is not more than six feet below the surface. Formerly basket willows were raised mainly along streams or ponds, but this practice has been largely abandoned, because wet-land weeds are likely to overrun the holt.

The soil best suited to willow culture in Germany is a sandy loam underlain with gravel or clay. For an ordinary farm crop, such as wheat or oats, considerable fertilizing and careful cultivation are required every year, but for willows fertilizing is unnecessary, unless growers desire to increase the vitality of the holt, when manure is spread over the holt, or compost placed along the rows in early spring.

Preparing the Ground

Much care is taken to prepare the ground thoroughly, since the success or failure of the holt depends upon this first step. In order to bury the weed seeds, the top layer of the soil is completely turned over. This is best done with a spade, though a plow is sometimes used. The soil is broken to a depth of twenty inches, and care is taken to bring on top the fresh soil from below. Where cultivation is thorough during the first two years, little, if any, subsequent weeding is necessary. The ground is prepared during the fall or winter, and is then in excellent condition for planting as soon as the frost is out in the spring. It is considered good practice to plant potatoes for a year before willows, in order that the soil may be thoroughly worked up.

Willows Grown

The willows generally grown and considered among the best are:

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COMMON NAME	BOTANICAL NAME
1. Common white osier	*Salix viminalis* L.
2. Yellow king osier	" " *regalis* (1)
3. Brown king osier	" " *cinnamonea* (1)
4. Fine osier	" " *gracilis* (1)
5. Equal-leaved osier	" " *aequalis* (1)
6. Purple willow	*Salix purpurea* L.
7. Common hybrid	" " x *viminalis* Wimmer
8. Almond willow	" *amygdalina* L.
9. Yellow almond willow	" " *vitellina* (1)
10. Gray almond willow	" " *praecox* (1)
11. Brown almond willow	" " *fusca* (1)
12. American willow	" " *americana* (2)
13. Long-leaved ash willow	" *dasyclodes* Wimmer (3)
14. Caspian (or Lemley) willow	" *pulchra* Wimmer et Krause

Common white osier is one of the most productive basket willows cultivated in Germany, because the rods are cylindrical, branchless, and extremely flexible. Peeled rods can be bleached almost pure white, and this makes them particularly desirable for fancy baskets. It is also a very good willow for use with the bark on.

Yellow king osier, also known as the yellow osier, produces an exceptionally good crop of high class rods which are almost entirely free of branches. The rods of this

(1) Authors of these varietal names can not be ascertained without further research. (Cited from Alfred Schmidt in his "Korb und Bandweiden," Stuttgart, 1898.)

(2) The standing of this name can not be determined without further investigation. It was printed without description or figure in 1901 in Wilhelm Hemmerling's "Die Kultur der Korbweide." In a brief study of the one-year-old shoots this willow was found to belong to the *Amygdalinae* group. It varies slightly from the form commonly called American green, and must not be ranked as a species, but should be recognized as a distinct variety and is here designated as *S. amygdalina americana.*

(3) *Salix dasyclados* Wimmer in Regensb. Flora, 1849, No. 3, is antedated by *Salix longifolia* Host. Sal. p. 19, 1828. Authorities are suspecting that this willow is a hybrid of *Salix viminalis* L., *S. caprea* L., and *S. cinerea* L., but this has not yet been fully determined.

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variety have a bright, yellowish-green bark. They are also used with the bark on.

Brown king osier has the same qualities as the yellow king osier, but is less extensively planted. The color of the bark is cinnamon brown, and the variety is often called cinnamon willow.

Fine osier is largely planted in west Germany and parts of eastern France. It has long, cylindrical rods and yields as large a crop as any of the other varieties belonging to the *viminales* group, but is somewhat more exacting as to soil conditions. It requires a moist and very rich, sandy loam for its best development.

Equal-leaved osier was introduced into Germany from France, and is one of the most productive varieties. Its leaves are shorter than those of other related varieties, and are of equal length on male and female plants. The rods are somewhat like those of the American green or almond. The osier* willows require a moist, porous soil. They are the true basket willows, but they have a rather large pith, and for this reason some varieties have been found to pay best where growers can find market for unpeeled rods. The osier willows have not been generally introduced in America.

Purple willow is so-called because the male flowers of this group of willows are purple. It is, perhaps, the most beautiful willow cultivated. It produces a good crop of slender and cylindrical rods used largely for fancy baskets, though the unpeeled stock is used in rough baskets for shipping market produce. The yield is good for the first six or eight years, but later the rods become short and thin. More than any other, this willow requires cultivation and care in keeping out weeds, because the foliage is thin, and grass and weeds are encouraged by the sunlight admitted to the soil. Rich, moist loam is particularly suitable for its best development. There are a number

* The term "osier" is frequently applied to any willow cultivated for basket rods. The best authorities apply it only to the willows belonging to the *viminales* group.

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of varieties of this species. The better ones yield the rods used for tying the grapevines to trellises in European vineyards. The rods are also the toughest for general wicker work. The bark contains a high percentage of tannin and is very bitter; therefore the purple willows are seldom damaged by insects or animals.

Common hybrid willow is also known as long rose willow. It produces long and tough branchless rods which are among the most desirable, in both the peeled and the unpeeled state. It thrives best in northern Germany and requires a medium good soil. This hybrid is much cultivated in England, where it is generally known as rose willow. It requires a light, sandy loam, inclining to clay, to grow most vigorously and to produce rods of best quality; in dry soil it becomes a mere shrub.

Almond willow, in many varieties, is successfully grown throughout Germany. The yield in weight per acre is higher than that of any other group. The rods are hard, have only a small pith, and are perfectly white when peeled. They have a tendency, however, to branch near the top and to prevent this they are planted rather close. The soil does not need to be very fertile, but it must be permanently moist. Several varieties are cultivated in Holland, where they grow very fast and produce rods that are unexcelled in length and flexibility. The stock is used for large hampers and other wares requiring heavy material.

Yellow almond willow makes a vigorous growth and produces long, slender rods which are easily peeled. It is extensively cultivated, and is known in many localities as yellow greveling. It is readily distinguishable by the yellowish bark. The peeled rods are almost pure white.

Gray almond willow is one of the first willows to sprout in the spring, and matures early. It is commonly known as May greveling. It is easily recognized by its large, glossy leaves and large stipules with numerous glands.

Brown almond willow is widely cultivated in western Germany, and its productiveness almost equals that of the

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yellow almond. It requires a moderately rich soil and, because of its dark colored bark, is used peeled. The wood is hard, has a small pith, and splits easily.

American willow is said to have originated in the United States. It has large, green leaves and a pinkish stem. It has been recently introduced into Germany, where it is now much cultivated, and will be planted more and more. It is seldom attacked by insects, and in this has an advantage over the varieties of the common white osier.

Long-leaved ash willow is largely used in Germany for binding material, and for this purpose the stools are set eighteen inches apart between the rows and six inches in the rows. After the second year, the young shoots develop into very strong rods with large pith, which are also used for basket ware. Recently it has been grown for peeled stock, as the rods bleach to a very clear white.

Caspian willow is grown in the United States. It is excellent for basket rods and for binding material. It thrives on moist, and even on dry, sandy land, where the rods grow long and slender and are almost pure white after peeling. It has a tendency to branch, so the cuttings should be planted close together.

Spacing Willow Plants

Basket willow growers in Germany adhere to the practice of spacing the plants six inches apart in the row and fifteen inches apart between rows. Several other spacings are used, but close spacing, in addition to the selection of proper varieties, is the key to producing the best quality of rods.

The low and rather rich meadow lands, suitable for willow culture, are also desirable for grass. In order to secure a crop of both from the same area, willows sometimes are planted in rows alternating with narrow strips of grass. Two rows of willows are planted, and the strips of grass between these double rows are about twelve feet wide, and are mowed regularly two or three times each year. This method is not used extensively, because only a few varieties

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of willows can be successfully grown in this way, since there is a tendency to spread out from the base toward the open grass area and to branch considerably.

In central and northern Germany there is another method of spacing. The regular spacing is similar to the six inches in rows by fifteen inches apart between rows, except that every sixth row is omitted, leaving a passage about thirty inches wide. This space facilitates walking through the holt and also admits of partial horse cultivation, but growers are gradually abandoning this method, since the growth of weeds is encouraged in these wide passages, and the rods develop more branches than elsewhere.

A number of holts are not cultivated at all, because of the recent increase in wages for farm hands and the scarcity of labor. Growers consider it cheaper and more profitable in the end to do little or no cultivation. The productive life of the holt is considerably shortened through this lack of attention.

Cultivating the Holt

In Germany, practically all weeding and cultivating of willows is done by hand and with a hoe. In holts where the ground is thoroughly prepared before planting, weeds are not troublesome, provided there has been cultivation during the first two years. The holts are divided into squares, and laborers are paid a certain rate to clean a square. From two to four cleanings may be necessary the first and second years, but one hoeing early in the spring should be sufficient thereafter. Some growers use small horse cultivators for breaking the soil between the rows, but this does not take the place of hoeing and weeding, since the weeds must be removed from between the stools in the rows. While thorough hand cultivation costs more than any other method, it is far more satisfactory. Where wild morning-glories (*Convolvulus arvensis* L. and C. *sepium* L.) are troublesome, women and children are employed to pull them up during July and early August.

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Harvesting the Willows

The rods are harvested under the supervision of the grower, and great care is taken to cut them close to the stool. Rods are cut with a very sharp knife about six inches long.

The processes of harvesting and the methods of preparing the rods for market have been very little affected by modern machinery. It is a light task to peel the rods, hence the work can be done by old or infirm persons. The apparatus for removing the bark, the "brake," consists of two iron rods about sixteen or eighteen inches long and about one-half an inch thick, welded together at the lower end, which is sharpened and inserted into a block of wood of convenient height. The peeler may sit or stand opposite this brake, and, by drawing the rods through several times, the bark is shredded off.

Marketing the Willows

Willow growers in Germany usually sell their rods on the stool. In the autumn, when the rods have ceased growing, basket-makers are notified that the crop is ready for inspection. They select the stock desired, and in early spring they cut and ship it. The price is calculated by the hundred pounds, dry weight, and depends upon the size of the grade; the thin, medium-size rods bring the highest price. An acre yields about 2,000 pounds of dry rods, which, at an average price equivalent to $4 per hundred, brings a gross return of $80 per acre.

Peeled willows are sold to basket-makers or to buyers for export. Only the best grades are exported. These are sorted very carefully, and the sorting may be done by the grower with little extra expense, but it considerably enhances the value of his product. In Germany peeled willows are made into baskets, crates, furniture, and other products, mainly for home use. Farmers use many baskets and hampers to bring their produce to market. Bottling establishments also use many baskets. The bulk of the rods, with the bark on, are made into baskets by local basket-weavers for export.

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In Europe more use is made of rough, unpeeled willow baskets than in America and countries where wood for packing boxes is plentiful. Large parcel trucks, trunks, and hampers for transportation are commonly made from unpeeled rods and render very good service. Farmers, grocers, fruit merchants, and dealers are fully convinced of the superior advantage of unpeeled willow-ware receptacles over those of splints or boards, and serious competition is not likely to arise between the two kinds of ware.

The Use of Basket Willow Bark

The barks of most basket willows contain sufficient tannin to make them valuable for tanning purposes. In Europe, and particularly in Sweden, Norway, Finland, and parts of Russia, the highest grade of tannin is produced from willow bark. Russia alone consumes annually no less than 20,000,000 pounds of willow bark. Many special kinds of leather, such as the Muscovy (Russia) leather and Danish glove leather, are prepared exclusively with tannin from willow bark, which imparts a characteristic odor, a light color, and considerable pliability. In Germany, Austria, and France, the use of this bark is increasing steadily. Yet up to the present time willow bark has had no market value in the United States. There is little doubt, however, that it will be widely used here for tannin as soon as its value is generally known. It is estimated that during the past year at least 1,000 tons of willow bark have been wasted in this country—material which might have been turned to economic use.

About one ton of dry bark may be obtained from an acre of basket willows, and it sells as high as $1.50 per hundredweight. Yet not all willow barks have the same value for tanning. The bark of large one or two-year-old rods is the best for the production of tannin extracts, while the corky bark of older trees is seldom used, because its tannin yields are small. In Russia the bark of sand willow (*Salix arenaria* L.) and of fever willow (*Salix fragilis* x *alba*

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Wimmer) are used most commonly. In central Europe the bark of several willows yields commercial tannin. Among the most important of these are the common white osier (*Salix viminalis* L.) and the almond willow (*Salix amygdalina* L.).

From a chemical standpoint the various willows may be divided into two groups; those with a large amount of salicin and those with a large amount of tannin. To the salicin group belong, in particular, the Welsh willows (*Salix viminalis* x *purpurea* Wimmer and *S. purpurea* L.), which have a tannin content of from 8 to 10 per cent. The tannin willows yield from 13 to 16 per cent. The Russian sand willow belongs to this group. The almond willow and related varieties contain from 10 to 16 per cent. of tannin. The bark of rose willow is largely used for the production of salicin. In preparing either tannin or salicin bark for market, it is cut into pieces ten or twelve inches long, dried thoroughly, and stored in a dry place, because bark which is allowed to become wet after it is dried loses its value as a source for tannin or salicin.

The dry bark of all willows grown in Europe is used as fodder for sheep and bedding for horses and cattle. It is also used in the manufacture of door mats, which outlast those made from straw and from rushes. The inner portion of the bark has recently been used in weaving a coarse cloth useful in the arts.

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Samuel Bowdlear Green

One of the most influential figures in American forestry, particularly in the field of educational work, was removed by the sudden death on July 16, 1910, of Samuel Bowdlear Green, dean of the School of Forestry at the University of Minnesota. Professor Green exerted a controlling influence in the development of the forest policy of Minnesota, succeeded in winning and holding the support of lumbermen in the state, and by persistent effort successfully built up the Minnesota Forest School from small beginnings until on May 13 last, only two months before his death, the school was made a separate department at the University. He was a man capable of working long and hard, and was wholly absorbed in his work. Yet he was by no means a fanatic. He understood the men with whom he had to deal, and patiently met the objections which they raised against his plans for the introduction of forestry and forest education. By persistence combined with tact and a genial temperament he was able to accomplish what he did, and at the same time to hold the respect even of those who did not agree with him. By his labors he laid the foundation in Minnesota for some of the most progressive work in forestry in the country.

Professor Green was born at Chelsea, Massachusetts, in 1859. He was graduated from the Massachusetts Agricultural College in 1879, and thereafter continued his studies in several foreign countries. In 1888 he became professor of Horticulture in the University of Minnesota, and in 1892 professor of Horticulture and Forestry. When the Forest School was made a separate department on May 13

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last, he became its first dean. He was president of the Minnesota Horticultural Society, of the Farmers' Institute, of the Arbitration Board in the switchmen's strike, was an active member of the State Board of Forestry, a member of the Executive Committee of the Minnesota Forestry Association, and chairman of the Curriculum and Grounds Committee in the Agricultural College. He was author of a number of books, including "Amateur Fruit Growing," "Vegetable Gardening," "Forestry in Minnesota," and "Principles of American Forestry."

In commenting upon his life and work the *American Lumberman* for July 23 said:

> Professor Green was essentially of a judicial temperament. He saw both sides of every question. He possessed the one faculty that is indispensable to leadership in any movement in which interests are varied and conflicting. He was not a radical partisan or advocate of any policy, party, or interest. He understood, recognized, and respected the rights and opinions of all. His advocacy was in the direction of education. He knew that the forests must be used to be conserved, and it was his chief end and aim to teach the people to know that true conservation of the forests is synonymous with their proper use. Thus in his policy the theoretical and practical were so combined and harmonized as not to arouse the antagonism or opposition of any interest. He had the fullest confidence and respect of lumbermen and all who knew him.

Louis Christian Miller

The sudden death of Louis Christian Miller, chief of the Section of Planting in District 2 of the Forest Service, at Denver, Colorado, on July 16, 1910, following an operation for appendicitis, is a great loss to the Society of American Foresters and his coworkers in the Government service.

Mr. Miller was born in Missouri August 17, 1873. His early boyhood was spent on a farm and amid logging operations in the hardwood forests of western Arkansas. He

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attended the public schools of that state and later of Oklahoma, and in 1900 graduated from the Oklahoma Agricultural and Mechanical College. The same season he entered the Bureau of Forestry as a student assistant and aided in a study of the growth of planted timber in Kansas. In 1901 he was first assistant in a party which studied forest conditions in Nebraska and located the Dismal River and Niobrara forest reserves. In 1902 he had charge in the field of starting experimental planting on the Dismal River Reserve. The winter of 1902-03 he spent as a student in the Yale Forest School and in the spring of 1903 passed the Civil Service examination for field assistant in the Bureau of Forestry, later receiving an appointment to that position. During 1903 and 1904 he conducted a study of the extent and importance of chaparral as a cover for watersheds in California. His capable work and executive ability led to his appointment on July 16, 1904, as chief of the Section of Reserve Planting, a position which he retained until he became chief of the Section of Planting in District 2.

Mr. Miller was thus connected with the Forest Service for ten years, and during this entire period of service was identified particularly with forest extension work. By reason of his long experience with the practical problems of this part of forestry he acquired a wide knowledge of the difficulties of reforestation work on the National Forests of the West and worked out a large number of the methods of nursery practice and field planting and sowing now employed in the Government work.

His untimely death, occurring just as he was beginning to reap the fruits of his work, comes therefore as a severe shock to all of his many friends.

Mr. Miller carried into his professional work that same spirit of whole-hearted enthusiasm and devotion to an ideal which characterized him in his private life. Always cheerful and optimistic, always ready to further the interests for which he labored by a spirit of enthusiastic coöperation, he

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represented a type which is by no means common—a man who was thoroughly engrossed in his chosen profession and at the same time so broad-minded and generous in spirit as to display in a marked degree the finer qualities of friendship and manhood which distinguished him from common men. Those of us who knew him will long cherish the memory of his genial personality.

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